Republic of Iraq
Ministry of Education
General Directorate of Curricula

BIOLOGY

6

Biological Branch

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Second Translated Edition 2023 /1445

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Translated from 9th Arabic edition

عزيزي الطالب :

الرسومات التي تحتوي على الرمز * تكون مطلوبة للحفظ وليست للاطلاع

PREFACE

Biology is a rapidly developing branch of science. The major advances being made continuously affect our life on earth. Some of these important advances are included here.
The results of a recent survey on the attitudes towards existing literature available to high school students showed that many were unhappy with the material used in teaching and learning. Those questioned identified a lack of the following: accompanying supplementary material to main text books, current information on new developments, clear figures and diagrams.

This book aims to improve the level of understanding of modern biology by inclusion of the following: main texts, figures and illustrations, extensive questions, articles and experiments. It is the intention and hope of the authors that the contents of this book will help to bridge the current gap in the field of biology at this level.

This book has been carefully reviewed and the language is considered suitable for students for whom English is a second language.

To the students

Being curious students, you may have wondered why you resemble your parents or why you need to breathe. In this book, I try to summarize some major subjects of biology. These are the most promising and perhaps the most complicated subjects of modern biology.

Group work will greatly enhance your learning abilities as well as give you an opportunity to share your knowledge and experience with your friends. I hope that, being assiduous students, you will work hard throughout this academic year and do your best to satisfy your scientific curiosity and, of course, to pass all of your exams successfully.

The author

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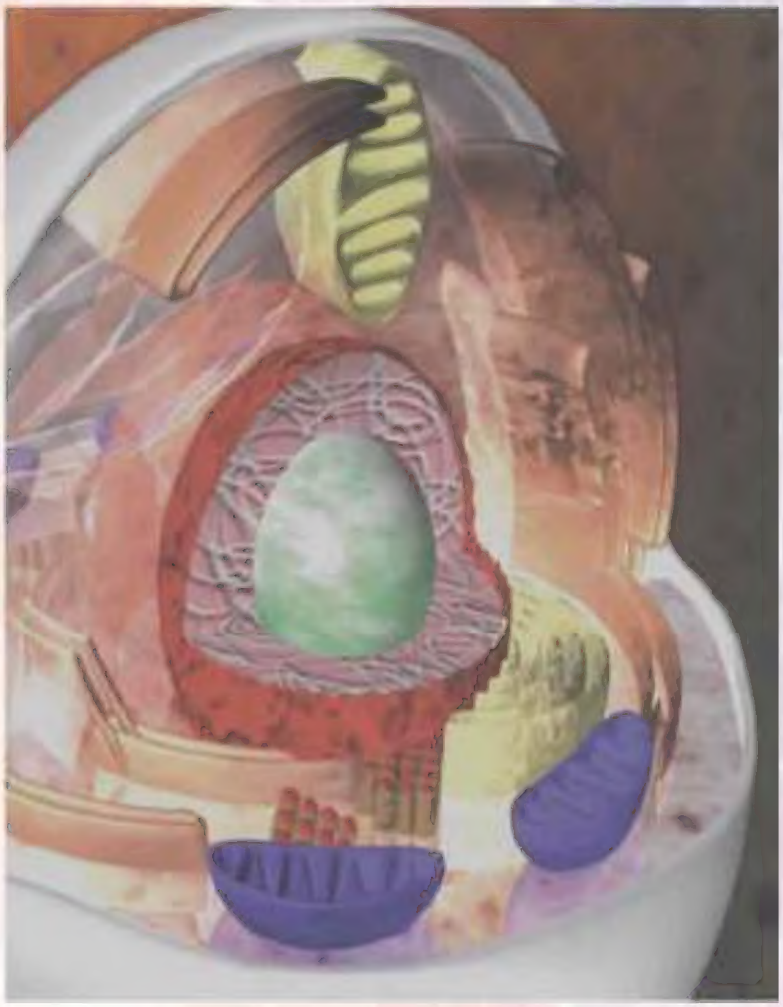
CHAPTER 1
THE CELL



Contents :

Objectives

1- Compare between eukaryotic and prokaryotic cells.
2- Determine the basis of cell theory.
3- Numerate the cell organelles and their functions.
4- Compare between cell wall and plasma membrane.
5- Know the mechanisms of cell activities.
6-Define the cellular respiration types.
7- Explain the concept of both mitosis and meiosis.

Introduction:

The cell is considered as the basic unit of all organisms. Generally, there are two types of cells from a structural point of view: the prokaryotic cell, as bacterial cell, which lacks nuclear membrane and membranous organelles. The second type is the eukaryotic cell which is larger than the prokaryotic cell and has clear nucleus surrounded by a nuclear membrane and cell organelles.

Figure 1.1 Simple microscope (for study)

The cell has been the centre of interest for a long time; scientists have a major role in development of cytology (i.e. the study of cells). Developments in cell study can be briefed as follows:

1. The cell was not known when the German scientist **Antoine Van Leeuwenhoek (1632 - 1723)** invented the microscope; he could be the first who saw the cell.

2. The English scientist **Robert Hooke (1635 - 1703)** has the same observations of Leeuwenhoek. Hooke is the first to use the word (cell) when he examined the structure of oak tree cortex. He described corky units and defined the cell as aerobic chamber similar to bee hive.

3. The Scottish scientist **Robert Brown** discovered the nucleus of the cell in 1831 and described it.

4. The German scientist **Mathias Schleidein** concluded that all plants are consist of cells in 1838.

5. The German scientist **Theodor Schwann** concluded that all animals are consist of cells in 1839.

Studies and researches into cytology have increased, particularly after advances in light microscope and invention of electron microscope, the study has become a major branch called **Cytology**.

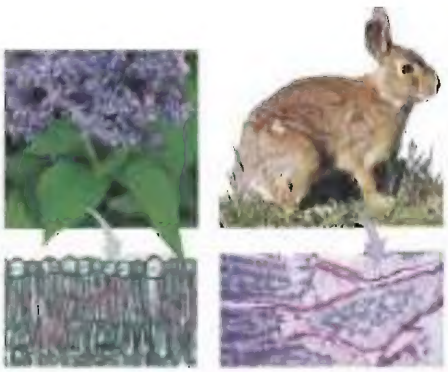


Figure 1.2 Types of tissues (for study)

Cell Theory

The cell theory is mainly based on the work of both M. Schleidein and T. Schwann, which can be briefed as follows:

a- All organisms are made of cell or cells.
b- Cells are the basic structural and functional units of all organisms.
c- The cell is produced from another cell by means of cell division.

Cell Size

Cells vary in size, for example, diameter of frog's egg is 1 mm, it can be seen by naked eyes. Most cells are smaller than 1mm.

Human egg is (100 micrometer) or less. Cells have specific specialties to increase efficiency of various functions.

We need microscope to see cell and micro-organisms. Cells can be seen by light microscope, but inner components of the cell like organelles, viruses and organic particles can only seen by the electron microscope.

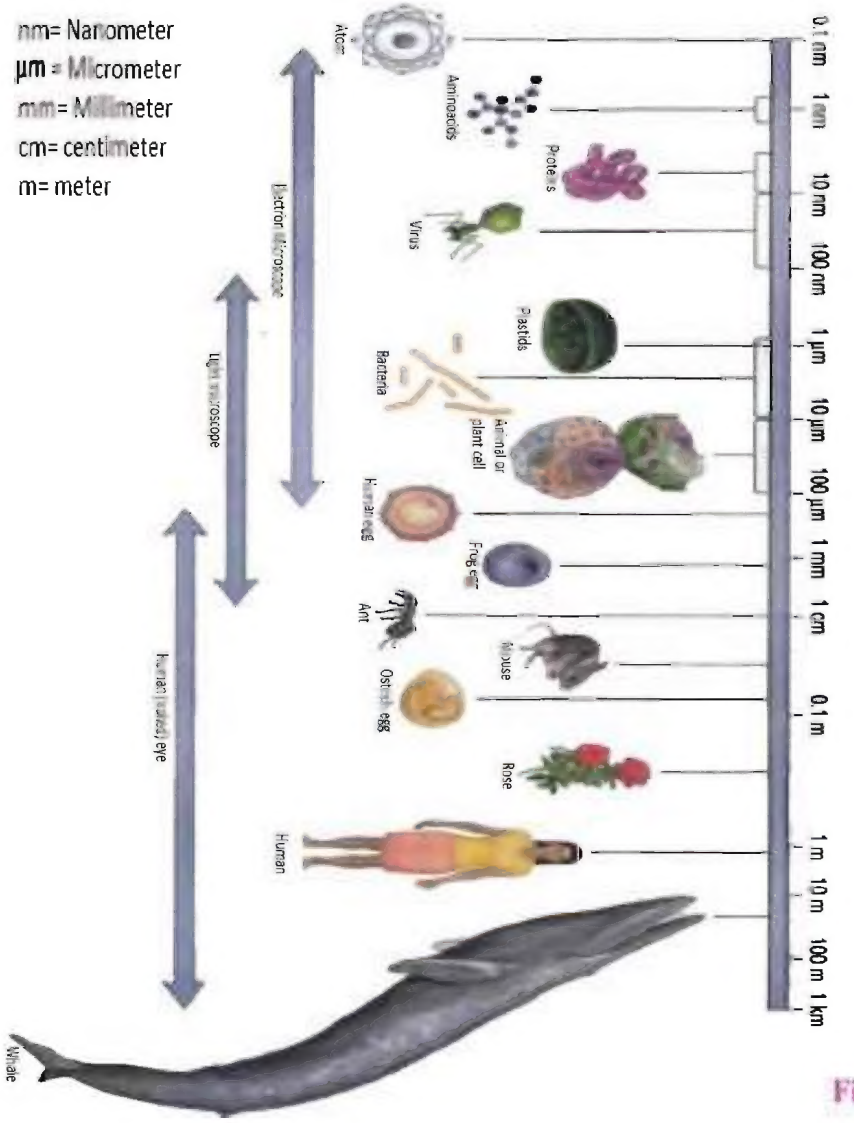


Figure 1.3 Sizes of living organisms and their components (for study)

Remember....!

All living things are made up of cell or cells. The cell is the structural and functional unit of organisms. This cell has ability to self-reproduction from previously existing cells.

Prokaryotic cell

It is undeveloped cell, it is more primitive in shape and structure, and characterized by the followings:

a. Prokaryotic cell has genetic material without a membrane and it is called as nuclear zone or **Nucleoid.**

b. Prokaryotic cell cytoplasm has no membranous organelles like Golgi bodies and mitochondria,It has ribosome in the form of numerous small grains, which build proteins .

c. Prokaryotic cell is represented by **blue green algae, bacteria** and **Mycoplasma** which all belong to kingdom **Monera.**

Each bacterial cell represents a prokaryotic organism. It is surrounded by a solid wall consist of chemical compounds (Protein, lipids and polysaccharides), behind this wall, there is the **plasma membrane** (it is a semi – fluid membrane) surrounds the cytoplasm, which contains the **nucleoid**. There are no nuclei or nuclear envelope, unlike eukaryotic cells. Cytoplasm also contains ribosomes. Some types of moving bacteria have **flagella**, **pili** or both.

Remember!

Bacteria differ from blue green algae because they have no chlorophyll pigment. Cell wall of bacteria is surrounded by capsule while blue green algae cell wall is surrounded by gelatin membrane.

Table 1-1 General appearance of bacterial cell

Structure	General appearance
Cell covering	- Cell wall - Plasma membrane
Cytoplasm	-Nucleoid - Ribosome
Suffixes	- Flagella - Fimbriae - Sex pili

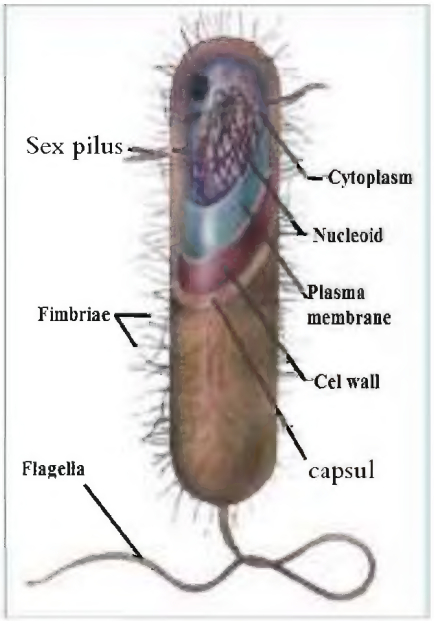


Figure 1.4 Structure of bacteria

Eukaryotic Cell

This cell has true nucleus, found in **Protists, Fungi, Plants** and **Animals.** Eukaryotic cells differ in shape; some are spherical, pyramidal, tubular, cubic, oval, flat, astral and fusiform…etc.

Some of these cells have varying shapes; they change from time to time like amoeba. Such change in shape is due to function of these cells, because cells often have shapes that adapt their functions. Eukaryotic cells are small and can only bee seen by microscope, but they are larger than prokaryotic cells. Generally, the cells need surface area (plasma membrane) to exchange materials with surrounding environment appropriately.

Eukaryotic cells consist of three major components:

a- Cell wall In plant cell and **Plasma Membrane** in both plant and animal cell.
b- Cytoplasm
c- Nucleus

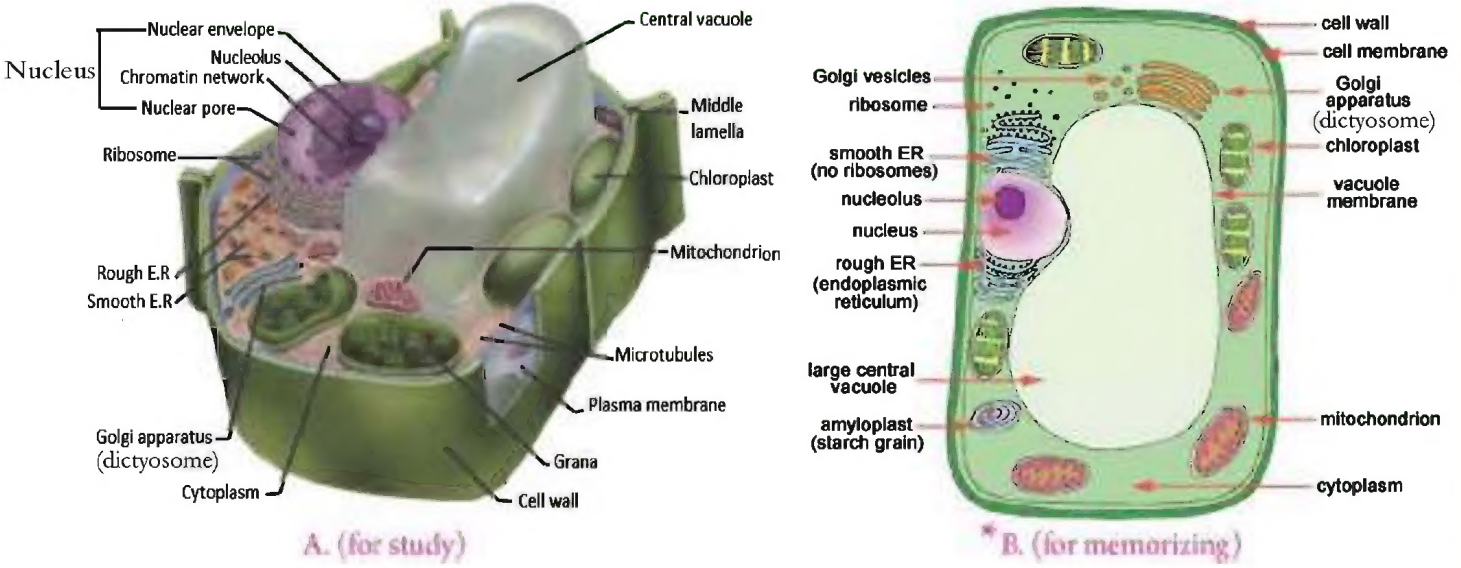


Figure 1.5 Structure of a typical plant cell

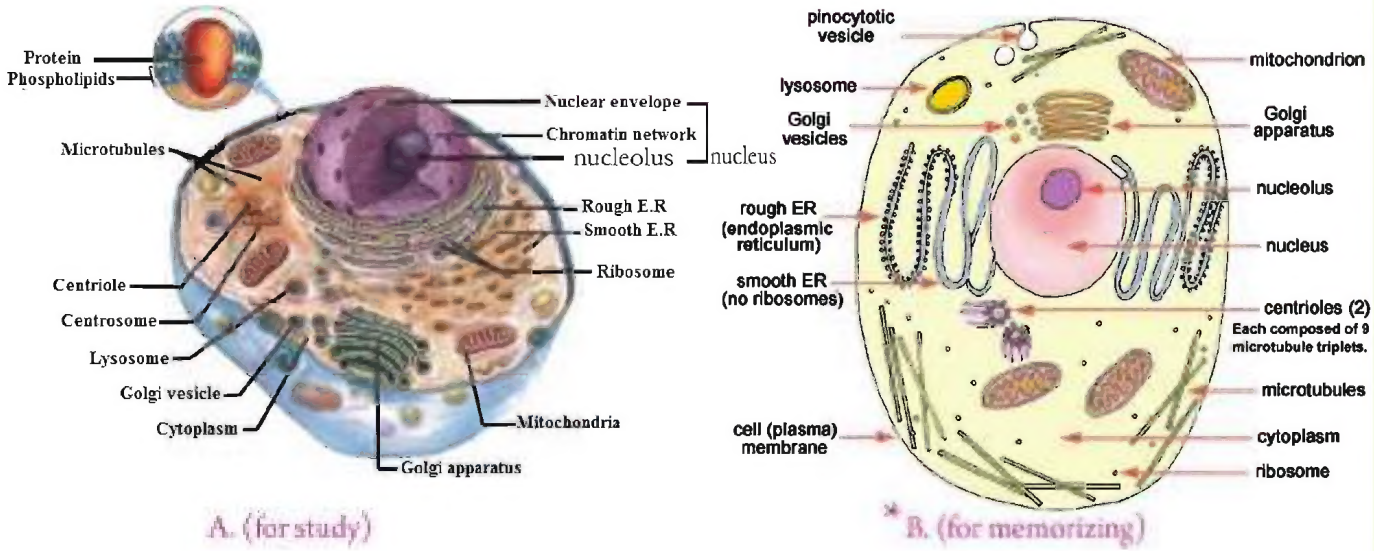


Figure 1.6 Structure of a typical animal cell

Cell Wall and Plasma Membrane

A-Cell Wall

Cell wall exists only in plant cells, it is an outer thick wall surrounding the cell, and it covers the plasma membrane, which lies inside. Cell wall provides protection and support to plasma membrane and cytoplasm.

Cell wall has three layers:

-Middle Lamella - Primary Wall - Secondary Wall

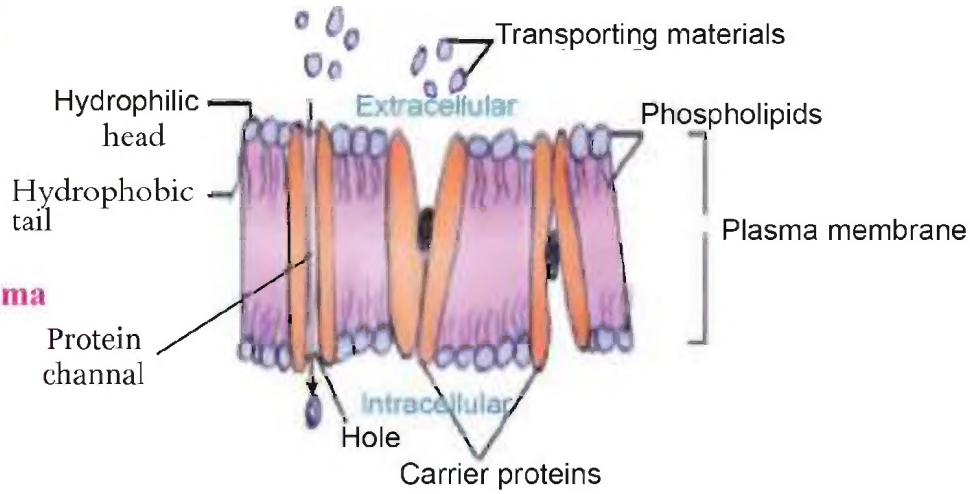
Chemically, plant cell wall consists of **cellulose** in young cells, and thickens when **lignin** is added in older cells.

B- Plasma Membrane;

Remember!

Plasma membrane is a selectively permeable membrane; it allows passage of some micro-particles and blocks larger particles.

It is a cellular membrane surrounding the cytoplasm in prokaryotic and eukaryotic cells. It is a flexible, thin and fluid membrane unseen by light microscope; it can be seen by electron microscope. Chemically, the plasma membrane consists of two thin layers of **phospholipids** with **hydrophilic** end and a **hydrophobic** end. The two layers are separated by protein particle that allows and controls passage of materials.



*** Figure 1.7 Structure of plasma membrane**

For your information

The plasma membrane surrounds the cell and marks its outer borders. It supports and protects the cell, and it blocks liquids inside and outside the cell.

Cytoplasm

Cytoplasm represents the part that lies between the plasma membrane and the nucleus. It is a complex material consisting of (**80 %**) water, (**15%**) proteins and (**5%**) fat, sugars and salts. Cytoplasm consists of many cellular organelles, which stand for living structures in cytoplasm. It also contains non-living components represented by particles formed by activities of cell organelles.

Living Components of Cytoplasm

1- Endoplasmic Reticulum

Endoplasmic reticulum has reticulate interconnected system of tubules and vesicles, attached to plasma membrane at certain places and attached to nuclear membrane at other places. Endoplasmic reticulum is the place where lipids, carbohydrates and proteins are made. It is called "**Endoplasmic**" because of branches and interlocks with each other. Endoplasmic reticulum is divided into two types:

A- Rough Endoplasmic Reticulum (RER)

This type of endoplasmic reticulum has ribosomes on its tubules; they look rough and granular. This type has active role in building proteins. They help transport materials inside the cell, especially to Golgi bodies. It also acts as a structural reticulum of intra-cytoplasm material.

Endoplasmic reticulum is the place where lipids, carbohydrates and proteins are made.

B- Smooth Endoplasmic Reticulum (SER)

Smooth endoplasmic Reticulum differs from rough endoplasmic reticulum in that they have no ribosome, thus, they are smooth. As in the case of rough endoplasmic reticulum, the smooth reticulum transfers materials inside the cell and acts as a structural reticulum of intra-cytoplasm material. The smooth endoplasmic reticulum has a vital role in detoxification of drugs and medications. They are the place for building and concentration of fats. Thus, they appear in cells of ovary, testicles and two adrenal glands. They secrete **steroid hormones.**

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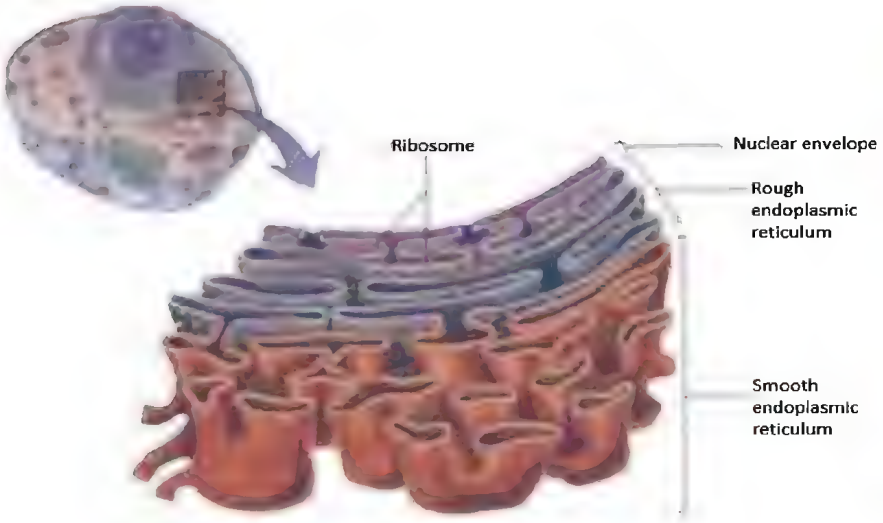


Figure 1.8 Smooth and rough endoplasmic reticulum (for study)

2- *Golgi Apparatus*

It is a secretory apparatus and first described by scientist Camillo Golgi in1898 while studying neurons. Golgi apparatus has a special location in the cytoplasm between the nucleus and plasma membrane. It is hard to identify its certain location and it differs in shape and size from one cell to another. Golgi apparatus consists of three chambers marked by smooth membranes, the first is (3 to 10) flat saccules called **cisternae**, the second is **vesicles** and the third is large **vacuoles.** Golgi apparatus has no ribosome.

Golgi apparatus is called **Dictyosome** in plant cell, it builds cellulose and some components of cell wall.

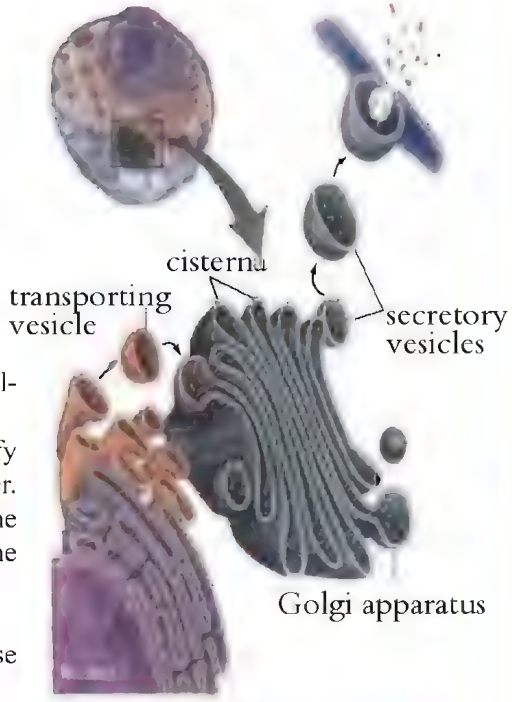


Figure 1.9 Structure of Golgi apparatus (for study)

In animal cell, Golgi apparatus has number of functions:

1- Building and secreting complex sugars

2- Secreting protein, which is obtained from endoplasmic reticulum but it does not produce protein.
3- Secreting many materials like hormones and enzymes.

Mitochondria are known as Energy houses because they are involved in producing ATP.

Thus, the basic function of mitochondria is cellular respiration, because they have respiratory enzymes.

3- Mitochondria

They are spherical or filamentous structures (**0.5 –1**) micrometer width and up to **10** micrometer length. They distributed in different cells. Mitochondria are found in eukaryotic cells, they differ in size according to the type of cells. Mitochondria are surrounded by double layer membrane. The inner layer has curves and folds of different shapes and directions, tops of these curves and bends are directed towards mitochondria cavity. These structures are called **Cristae.** They increase surface area of the inner layer.

Mitochondria are known as energy houses because they are involved in producing high-energy Adenosine tri-phosphate (ATP). Thus, the basic function of mitochondria is cellular respiration, because they produce respiratory enzymes.

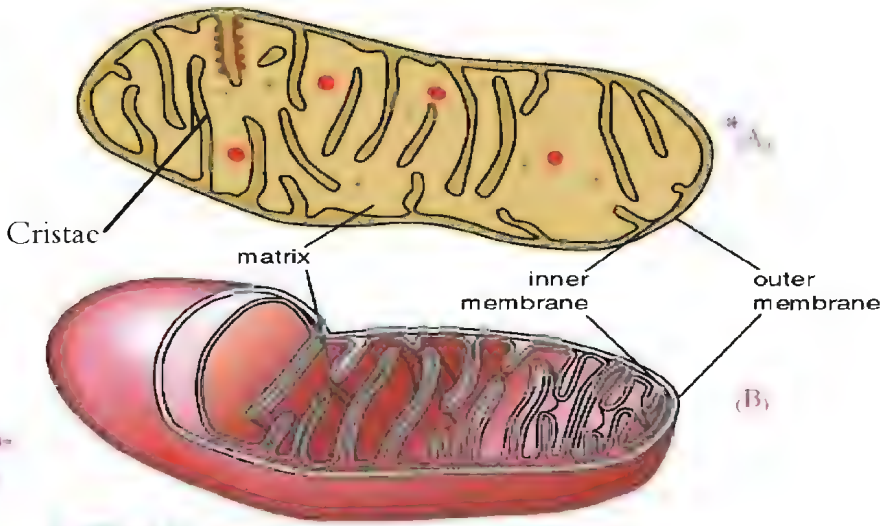


Figure1 (1) Structure of mitochondria: (A) for memorizin (B) for study

4- Plastids

They are cellular organelles in cytoplasm of plant cell. They have different shapes, sizes and colours. They can be oval, calyx, spiral and astral. Plastids are of three types:

a. Chromoplasts, which contain different pigments, these pigments, give colours to flowers and fruits.

b. Leucoplasts, which are centres for converting glucose sugar into polysaccharide like starch or into fats or proteins. The white matter in potatoes, for example, results from colourless plastids and full of starch.

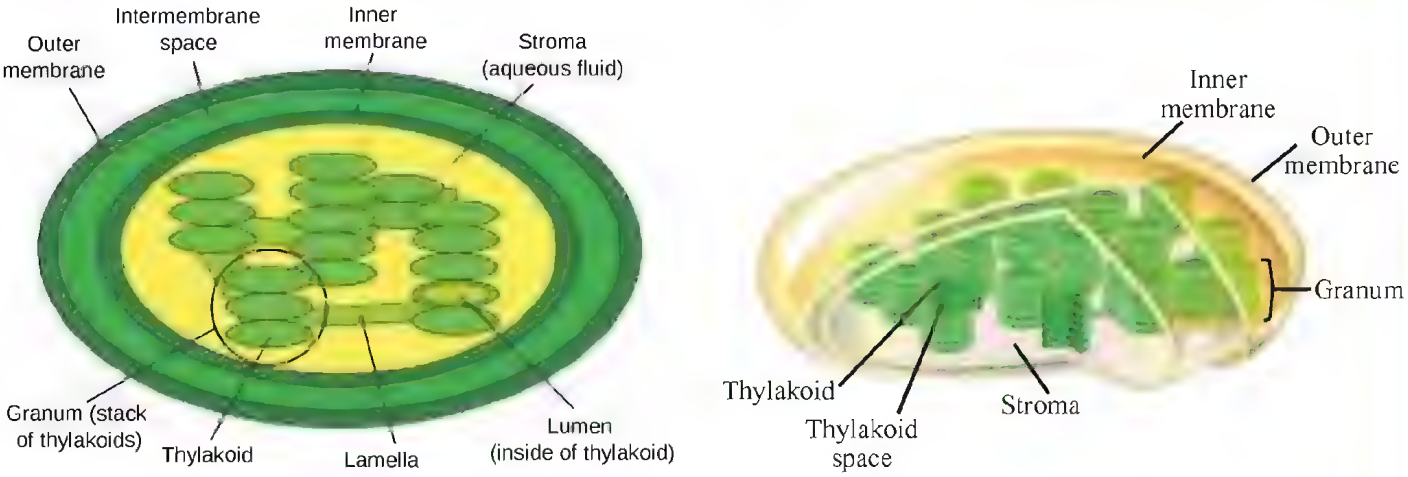
c. Chloroplasts:

They are common in plants. Chloroplast, just like mitochondria, is surrounded dual layer membrane.
Inside the membrane, there are two structures: the **Granum** (pl. **Grana**) and

the **stroma**. Stroma is the liquid transparent material, which fills the inner space of the plastid; it contains the grana, which contains chlorophyll. Chloroplasts contribute in photosynthesis; this process needs pigments to absorb solar energy , and enzymes to produce carbohydrates. These pigments (Chlorophyll) for example, exist on the grana membrane. CO_2 – reducing enzymes, which exist in the stroma, help chloroplasts with photosynthesis process.

Chromoplast gives different colors to the fruits and flowers while leucoplast converts and stores glucose in form of different complex organic material.

Thylakoid Membrane: A capsular structure formed by the inner membrane of the plastid. It contains chlorophyll and enzymes, which help in photosynthesis.



* (A) for memorizing (B): for study

Figure 1.11 Structure of chloroplast

5- Lysosomes

They are vesicles surrounded by mono-layer membrane. It contains many lysis enzymes (over 40 enzymes). These enzymes are responsible for digestion in the cell. Lysosomes are found in almost all cells, especially those that have the ability for **phagocytosis**, such as **neutrophils**.

Lysosomes have several functions in the cell:

1. It cleans cytoplasm from food particles, mitochondria pieces and micro-organisms and other impurities.

2. Lysosomes play a vital role in animal **metamorphosis**, for example frog larvae tail disappear when become adult frogs. This process is done by releasing enzymes from lysosomes to cytoplasm. This process digests the contents of the cytoplasm and finally death of the cell by a process called **Autolysis**. This process lyses bodies of living organisms after death.

3. Lysosomes destroy the cell which contains them after death of the organism.

4. They recycle elements in nature through **autolysis**.

Metamorphosis is sudden changes happen in body of organism. This process is done by releasing enzymes from lysosomes to cell cytoplasm. This process digests the contents of the cytoplasm and finally death of the cell by a process called **Autolysis**. This process lyses bodies of living organisms after death.

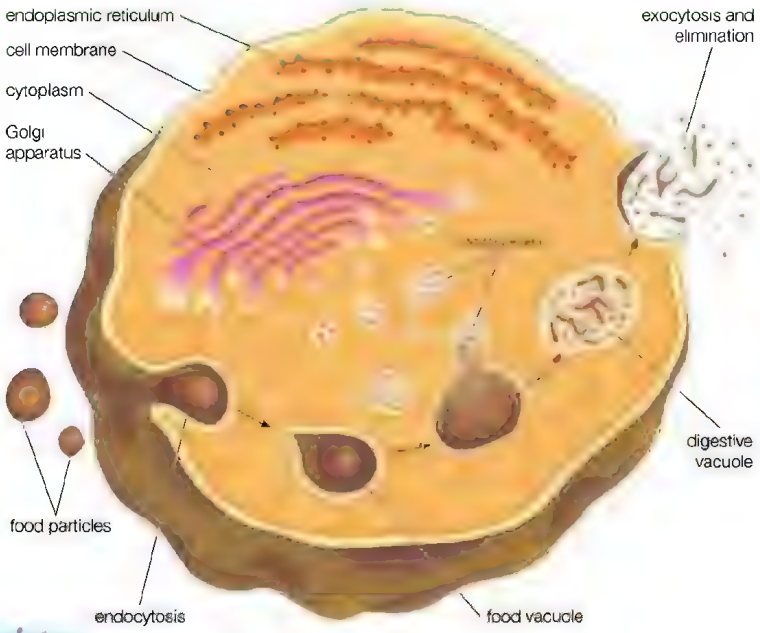


Figure 1.12 Lysosome

6- Cytoskeleton

Eukaryotic cells have a distinctive system of micro filaments and tubules, which form the skeleton of the cell. These are considered as support to the cell maintaining its form. This system is used by many cells in moving and transferring organelles inside the cell.

Microtubules are major elements in formation of **cilium, flagella and centrosomes**.

a- Microfilaments

They are thin straight structures first observed in muscular cells. They are **actin** filaments, which contain actin protein, the other type is **myosin**, which contains myosin protein, and both are responsible for expansion and contraction of cell.

b- Microtubules

They are larger than micro-filaments and have tubular structures consisting of protein called **tubulin**. Microtubules play vital role in chromosome movement during cell division. In addition, they are important for cytoskeleton, organization and transfer of materials. They are major elements in formation of **cilium** and **flagella**. Microtubules, which exist in animal, cell cytoplasm and other primitive organisms like algae and fungi, are situated near the nucleus and form the "**centrosomes**".

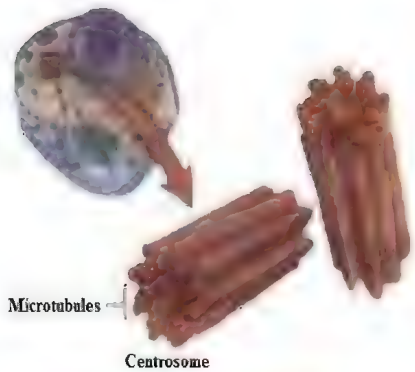


Figure 1.13 Centrosome (for study)

7- Centrosomes

The centrosome has a pair of **centrioles**, each of which is a cylinder consisting of nine triple- groups of microtubules. The centrosome duplicate during cell division; the two centrosomes move a part to the opposite sides of the cell and connect together through spindles fibres. Although centrosomes are not found in plant cell, yet, there is a centre for creating microtubules and micro filaments.

8- Kinetosome

It looks like **centriole** in structure. It is structure at the base of the cilium and flagellum in cells, which contain cilium, or flagella. The kinetosome has a vital role in movement of cilia and flagella; it is also called **basal body.**

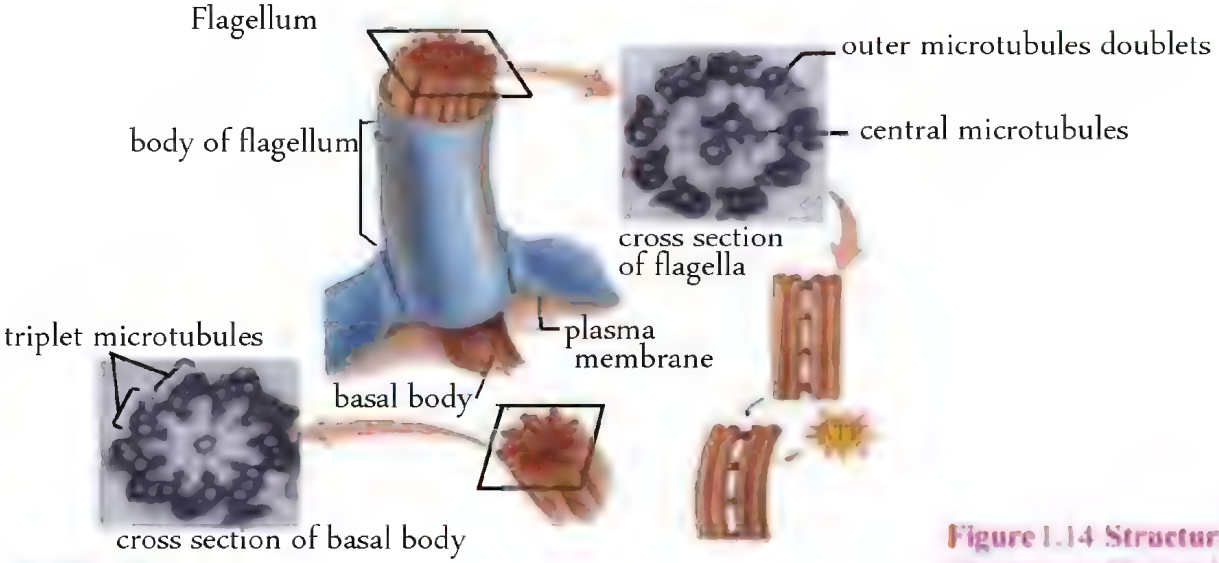


Figure 1.14 Structure of kinetosome (for study)

8- Vacuoles

They are membranous sacks that exist in cell cytoplasm and vacuoles in some protista, whereby it is represented by **contractile vacuoles** which drain cells from surplus water and dissolved waste such as **amoeba** and **paramecium**. There are also **temporary food vacuoles** formed when food is surrounded by a membrane of the living organism. Food is digested inside these vacuoles by secreting enzymes from lysosomes inside the vacuole. As for plant cells, the vacuoles are clearer than those in animal cells, they are small in young cells and wide in adult cells. They contain juices of different dissolved materials known as **Cell Sap**.

There are 3 kinds of vacuoles:

- Contractile vacuole
- Temporary food vacuole
- Storage vacuole

Non-living Contents of the Cell

They are temporily contents in cytoplasm called **cytoplasmic deposits.** They are mainly formed by metabolite materials or piled deposits. These deposits have several forms:

1. **Lipid droplets** in fatty (adipose) tissue cells and liver cells.
2. Carbohydrate accumulation represented by **glycogen** as in liver cells.
3. Proteins stored in glandular cells in the form of **secretory granules**, these granules are periodically released outside the cells.
4. Deposits of **pigments** and colourings, some cells produce pigments as in the skin cells.
5. Enzymes, hormones and some vitamins are also cytoplasmic deposits which are granular, spherical or oval. These materials are surrounded by membrane as in the case of neuro-secretory granules.

Nucleus

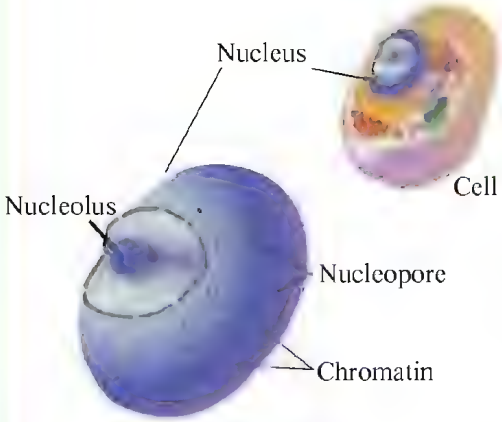


Figure 1.15 Structure of nucleus (for study)

The nucleus is the most important cell component in living organisms. It is essential for life; cell survival depends on exchanges between nucleus and cytoplasm. The cell without nucleus lives for a short time then degenerates like, adult red blood cells. Cell nuclei show variance in shape, this variance has to do with cell shape, it might be spherical or oval or lobed or irregular, like white blood cells. The nucleus is the largest distinctive organelle inside the cell and its size differs according cells. Its size depend on size of cytoplasm. Most cells are mono-nuclear cell. In some cases, the cell can be di-nuclear like cartilage cells, liver cells and muscle cells. The nucleus is central in stem cells. It has side or peripheral location in some secretory cells like fatty cells and mucous cells. The nucleus consists of the following components:

Most cells are mono-nuclear cell. In some cases, the cell can be di-nuclear like cartilage cells, liver cells and neuron cells.

1. Nuclear Membrane or Envelope

It is a thin, double -layer membrane. It surrounds the nucleus and it has its own physical and chemical properties. It regulates exchange of materials between the nucleus and cytoplasm through micro pores that allow passage of particles, this membrane has selective permeability. This membrane surrounds the nucleus in all cells except for bacteria and blue green algae (prokaryotic), it has no nucleus but it has nuclear matter.

2. Nucleoplasm

It is colourless gelatinous liquid fills the nucleus where the nuclear contents are distributed. These contents include nucleolus and chromatin network.

3. Nucleolus

The nucleus has one or more nucleolus. For example, onion cell nucleus has four nucleoli. The nucleolus is a relatively big spherical structure inside the nucleus. It consists of protein and RNA. Nucleolus has vital role for formation of ribosome, which is responsible for protein formation.

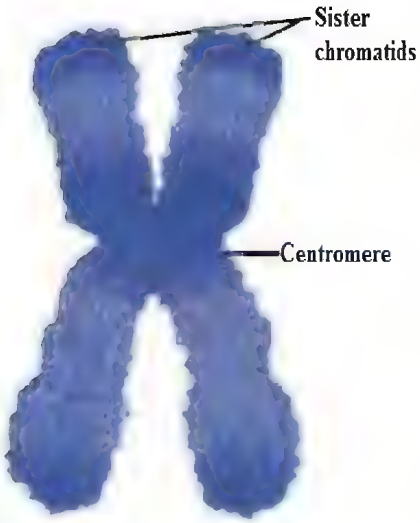


Figure 1.16 Structure of chromosome

4. Chromatin Network

The chromatin network is an interconnected and irregular filamentous structure. Filaments of the chromatin network appear during cell division, forming a specific number of rod- like structures known as **chromosomes**; they carry genes, which transport genetic features from one generation to another. Therefore, chromosomes are very important because of vital role in genetics, reproduction, development and mutation. Chromosomes can be seen only during cell division, the number of chromosomes differs in living things.

Living beings have a fixed number of chromosomes in their somatic cells. In Ascaris lumbricades , there are **2** chromosomes only; it is the least number of chromosomes among organisms. The number of chromosomes in the Spanish butterfly is **380**, **12** chromosomes in house fly, **26** chromosomes in frog, **80** chromosomes in pigeon and **64** chromosomes in horse. As for humans, they have **46** chromosomes.

It must be noted that these numbers of chromosomes represent somatic cells. Numbers of chromosomes in gametes or reproductive cells is half. For example, human egg has 23 chromosomes, while somatic cells have 46 chromosomes, **23 X 2 = 46**. It results from fusion of egg cell with sperm nucleus. Chromosomes have fixed size and shape in living organisms, its length ranges from (0.2 – 50) micrometer.

Comparison between Animal and Plant Cells

Animal and plant cells differ in some areas; table (1-2) shows the basic areas of similarity and difference between animal and plant cells from a structural point of view.

Table 1-2: A comparison between Animal and plant Cells

	Character	Plant Cell	Animal Cell
1	**Cell Wall and plasma membrane**	A thin plasma membrane along with thick cellulose wall consisting of lignin, giving the cell fixed shape.	Thin plasma membrane only.
2	**Plastids**	There are chloroplasts associated with photosynthesis; some are Leucoplasts, white plastids and colored plastids.	No plastids
3	**Centrioles**	No Centrioles, with the exception of some primitive plant cells	Centrioles exist in many animal cells, has a role in cell division.
4	**Vacuoles**	Vacuoles are few in plant cells, large. Vacuoles occupy the whole size of adult cell.	There are many vacuoles in animal cell, small in size, spread in the cytoplasm.
5	**Cell Division**	During cell division, the cellular plate is created. This plate grows from the center outward; it is generated by cell protoplast.	During cell division, the cytoplasm bends from the outside and moves inside.

Cell activities

Cells, whether plant or animal, achieve many activities, these activities can be summarized as follows:

First: Exchange of materials through membranes:

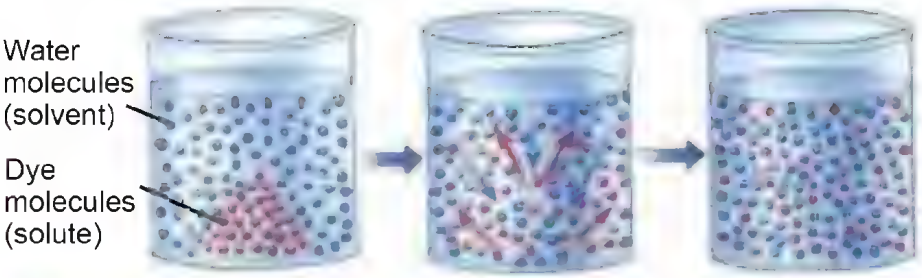
Exchanging of materials inside and outside the cell is considered the basic cell operation. This operation regulates cellular functions and determines exit of waste materials and water outside the cell. It is essential to maintain biological operations of the cell and construction of living matter. Passage of materials is done via many ways:

1-Diffusion

Diffusion is defined as movement of ions and particles in a certain medium, from high concentration regions to low concentration regions.

As a rule, gases like O_2 and CO_2 materials soluble in fats like **hydrocarbons** and **alcohols** are the soluble that can spread through bio-membranes (cell membranes) freely. This can be observed by the naked eye when **copper sulfides or Potassium Permanganates** are placed in water, the coloured material spreads through the water when crystals of above materials dissolve in water. Colored material spread on a short distance and it hardly spread for a long distance. Distance of spreading particles is directly proportional to square root of time for spread. With passage of time, matter will spread all over the water.

Figure 1.17: diffusion process



2-Permeability

Permeability is exchange of materials between the cell and its environment.
All food materials should have certain solubility in water to pass this membrane.

It is exchange of materials between the cell and its environment by aid of plasma membrane. The cell can absorb food materials in an appropriate food medium. This does not mean that food outside the cell can all be absorbed by the cell. These materials must pass through the plasma membrane. In addition, these food materials should have certain solubility in water to pass this membrane. Similarly, excess materials and faeces should dissolve in cytoplasm to pass through the membrane out of the cell.

Generally, membranes are classified according to permeability into:

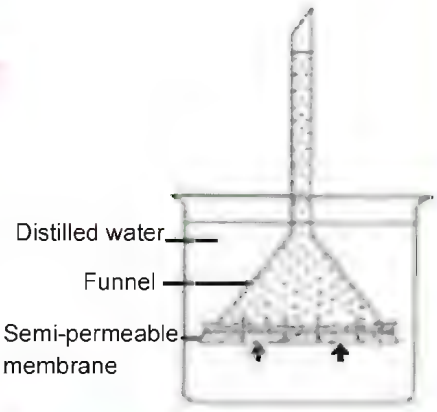
1. Permeable membranes: These membranes allow passage of materials regardless of their structure and size.
2. Semi - permeable membranes: These membranes do not allow equal passage of solutes as level of solvents.
3. Selectively Permeable membranes: These membranes allow selective passage of materials according to size of their particles.
4. Non-permeable membranes: Like nylon. It must be noted that permeability of plasma membrane is affected by internal and external factors.

3- Osmosis

It is defined as movement of water particles through semi permeable membrane (plasma membrane) according to variance in concentration. Movement of water particles is done according to diffusion law, because osmosis is a case of diffusion.

To clearly illustrate osmosis, we can do a simple experiment, using semi permeable membranes like cellophane attached at the end of a funnel. The funnel is filled with distilled water, and then placed in a glass basin. Water level should be the same in the basin and the funnel.

When sugar solution is added to the funnel, water level rises in the funnel. It indicates that water passes cellophane membrane to the sugar solution in the funnel, causing **hydrostatic pressure.** Water particles stop when hydrostatic pressure becomes equal to osmotic pressure. Solutions can be classified according to osmotic concentration into three types; each type has a particular effect in the cell:

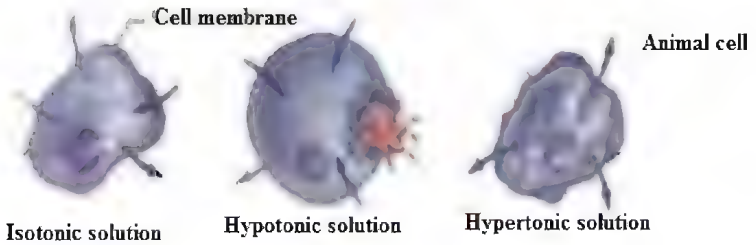


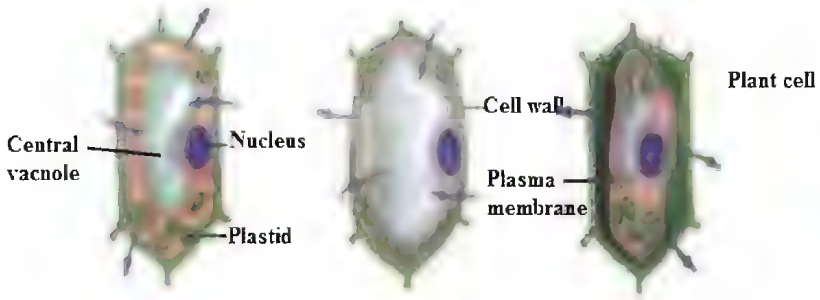
* **Figure 1.18 Osmosis mechanism**

a. Isotonic Solution whereby, concentration of water outside the cell is equal to concentration of animal cell cytoplasm, the cell neither loses nor gains water.

b. Hypotonic Solution: this solution has low concentration of non-permeable solutes compared to solutes in cytoplasm. The cell gains water, this leads to distention of the cell and then rupture.

c. Hypertonic Solution: this solution has high concentration of solute materials compared to cytoplasm, thus, direction of water is from cytoplasm to the outer solution, this causes shrinkage of the cell. The size of plant cell, compared to animal cell, does not change when placed in high hypertonic solution because plant cells have cell walls. The cell membrane merely moves away from the cell wall, this process is called **plasmolysis.** it results from water leaving the cell, but, when the solution is added to the cell, it goes back to its previous state. This reversed process is called **deplasmolysis.**





* **Figure 1.19 Osmosis in plant and animal cell**

4- Active Transport

Cells, sometimes, absorb materials from the outside environment, although, the concentration of these materials inside the cells is higher than outside. To perform this process, there must be carriers in cell membrane. These carriers can move inside and outside the cell. The carrier integrates with other material (particle or ion) needed by the cell.

This carrier moves to the inner surface of the membrane. The carried material separates inside cytoplasm. This process requires energy, which is supplied by **ATP**.

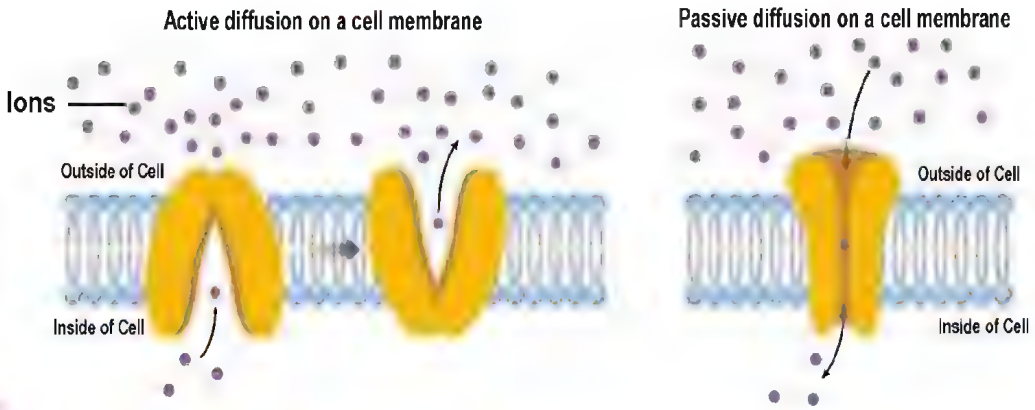


Figure 1.20 Active transport

5-Phagocytosis

Phagocytosis is cellular eating; it is a common way of eating (nutrition) among protista like amoeba. It is also used by white blood cells in devouring remaining cells and germs in the blood. This process is done when cell membrane is pouch-like that surrounds the solid matter, then this pouch separates from cell surface and moves inside cytoplasm. The contents are digested by the enzymes secreted by lysosomes in the cytoplasm.

6- Pinocytosis

It is similar to phagocytosis. When a liquid material is taken, there will be a small invagination in cell membrane, this hole surrounds the liquid matter, and becomes inside a **pinocytic vesicle**. This vesicle separates from cell membrane and moves inside the cell.

7- Exocytosis

This term is used to describe the releasing of some materials outside the cell. This process takes place in various cells to get rid of undigested left overs from phagocytosis, or to secrete some hormones.

Second: Cell Metabolism

Cell metabolism is represented by all the chemical changes, which take place with the help of enzymes. These changes are **catabolism** which means ;degradation of materials and **anabolism** which means building new compounds. Anabolism usually consumes energy, while catabolism releases energy, for example, Glucose particle anabolised from $CO_2 + H_2O$ needs energy. Green plants obtain this energy from the sun. While catabolism of glucose particle in respiration releases the energy required by the living organism in many activities.

1- Respiration

Glucose is the primary respiratory material; it undergoes a series of reactions to transform into two molecules of **Pyruvic Acid** during a process called **glycolysis**. This process is performed in cell cytoplasm because there are enzymes.

Glycolysis is summarized as follows:

1. Glucose molecule activation (6C) by phosphorylation to transform into glucose - 6 - phosphate, the process consumes 1 molecule of ATP.

2. Glucose - 6 - phosphate (6C) is transformed into fructose mono-phosphate (6C) by means of a specific enzyme.

3.Fructose - 6 - phosphate (6C) is activated by a second phosphorylation to transform into fructose di-phosphate, this process consumes 1 molecule of ATP.

4. Fructose 1.6 bi-phosphate molecule (6C) splits into two glyceraldehyde 3-phosph--ate molecules, because of this fission (split).

5. Each Glyceraldehyde 3- phosphate molecule is changed into pyruvic acid (i.e. becomes two pyruvic acid molecules). Although, four ATP molecules result from this transformation, two of them are consumed in phosphorylation, thus, the gain is two ATP molecules.

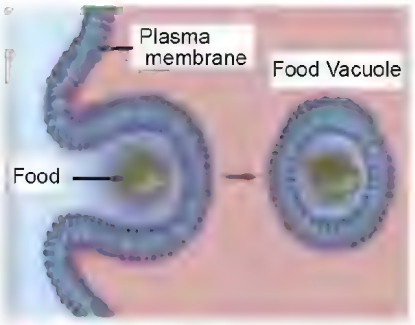
6. If respiration is anaerobic, the pyruvic acid has either alcoholic fermentation or lactic fermentation in cell cytoplasm.

However, if the respiration is aerobic, the **Pyruvic acid** turns into (**Acetyl Co- A**) which reacts in a cycle called as **Kreb's Cycle** in cell mitochondria. Below is a description of **aerobic** and **anaerobic** respiration reactions:

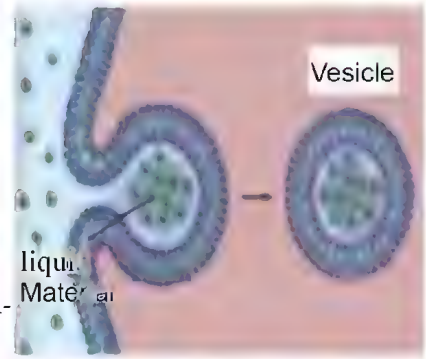
First: Anaerobic Respiration: It includes:

a. Alcoholic Fermentation:

It takes place in yeast and green plants due to lack or absence of O_2, and in some types of bacteria. The pyruvic acid is oxidized by taking CO_2 molecule, and then reduced by hydrogen from glycolysis, turning it into **Ethanol alcohol**, as in the following equation:

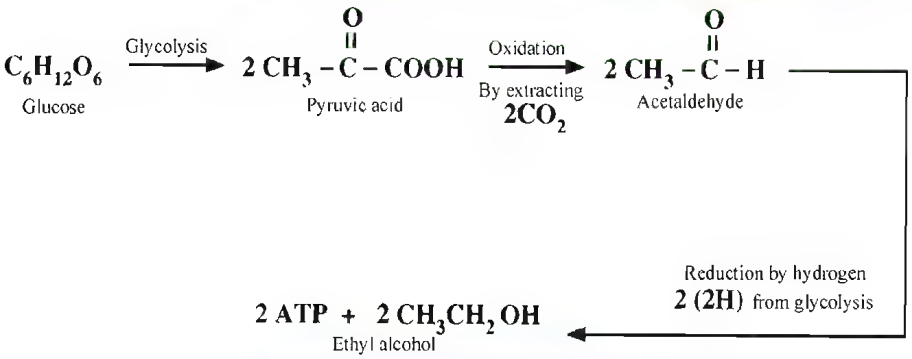


(A) Phagocytosis



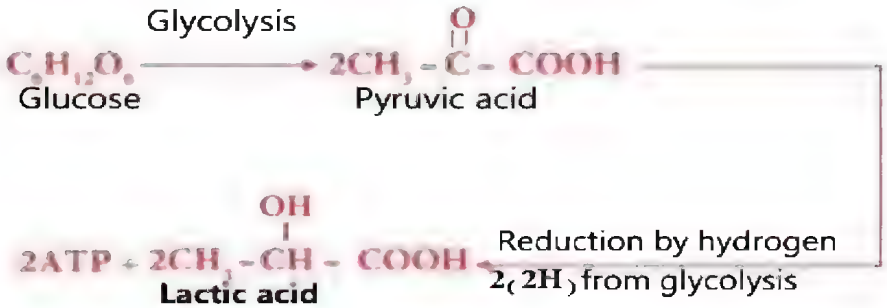
(B)Pinocytosis

Figure 1.21 : Phagocytosis process



b. Lactic Acid Fermentation

It happens in muscles and kinds of bacteria (lactic acid bacteria) during which the pyruvic acid resulting from glycolysis is reduced by means of hydrogen also resulting from glycolysis; as a result it change to lactic acid as in the following equation.



Second: Aerobic Respiration

When the pyruvic acid turns into Acetyl Co-A due to glycolysis, Acetyl Co-A enters in Kreb's cycle, in a series of reactions that release the whole energy: 12 ATP in each cycle. To brief, energy released from oxidizing one-gram molecule of glucose sugar during aerobic respiration is as follows:

2 ATP
Energy Gain from Glycolysis
(2x3ATP) 6 ATP
Transforming Molecules of Pyruvic Acid into Acetyl CO-A
(2x3ATP) 6 ATP
From2(2H)resulting from glycolysis after passing through electron transport chain
(2x12ATP) 24 ATP
From Krebs two-Cycles
Total: 38 ATP

Anabolism: Reduction of CO_2

CO_2 is one of the major outputs of aerobic and anaerobic respiration, although respiration is considered as catabolism, yet it produces chemical energy that stored as (ATP). This energy is used in many important activities like muscle movement. This energy is also used to form complex biological materials as a chemical process. Plants reduce CO_2 in the form of organic materials using solar energy, as you know; plants absorb CO_2 using water and solar energy to produce carbohydrate materials. terials. This reaction is called terials. This reaction is called **CO_2 reduction**. This reaction forms all complex organic molecules, thus, this process is considered as anabolism of organic materials.

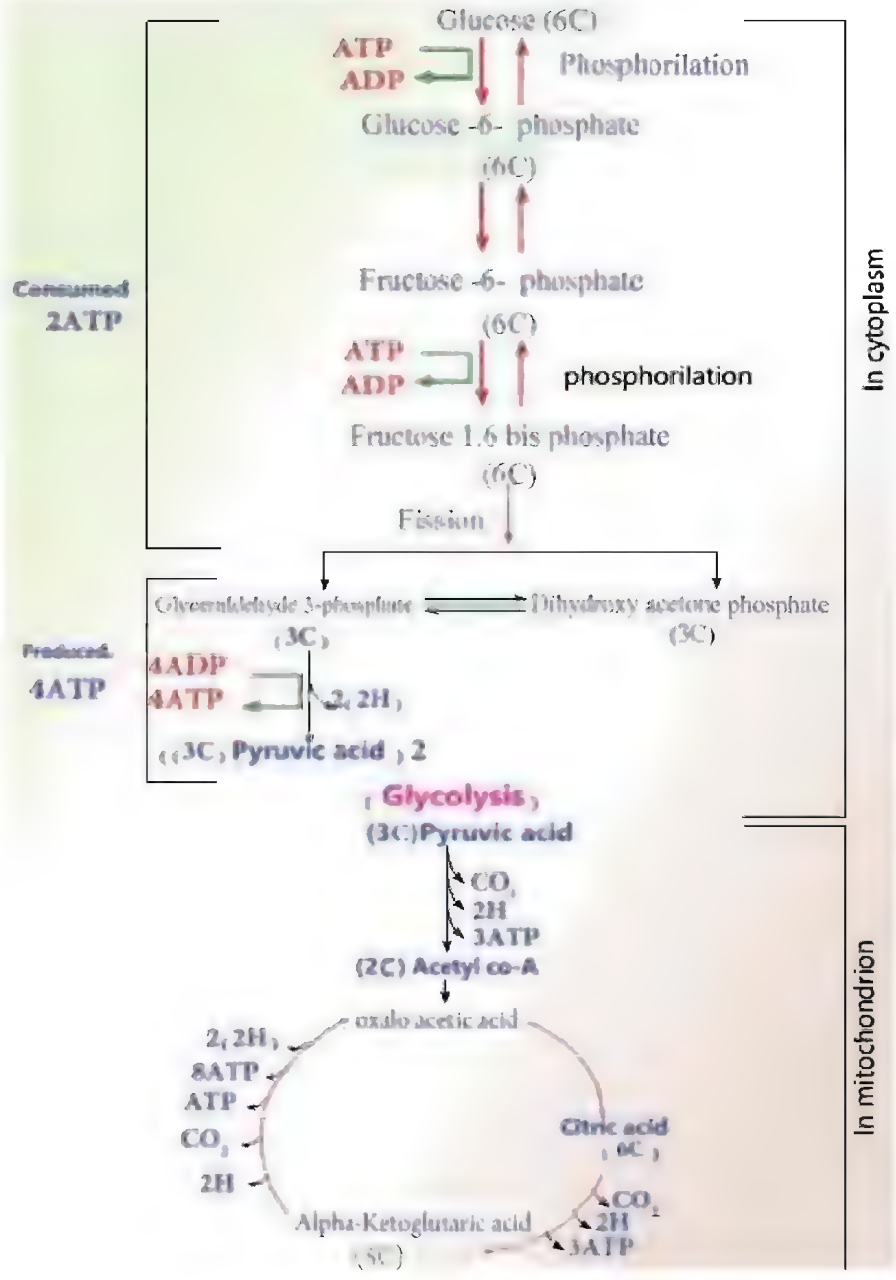


Diagram 1.1 The sketch of cellular respiration (Glycolysis and Krebs cycle)

Cell Division

Cell division is considered as one of the complex processes, which multiply (increase) the genetic matter qualitatively, and ensure homogenous distribution among the resulting cells. There are three types of cell divisions:

Amitosis

In this type of division, the cells divide without clear nuclear or cytoplasmic changes. The nucleus or nuclear matter and cytoplasm constricted and then split to form two cells, each of which contain part of the original nucleus or the nuclear matter and part of the original cytoplasm. This type of division occurs in bacteria and blue green algae.

Mitosis

Mitosis is defined as cell division in which both of new cells have the same number and quality of chromosomes of the mother cell.

Mitosis requires doubling of each chromosome to form two identical and adjacent chromosomes as if they are one chromosome. When cell division starts, the two chromosomes part from one another and separate in advanced phases. Division of nucleus is followed by **cytokinesis**. For example, human cell has 46 chromosomes. They duplicated before division to be **92** chromatids. when division completed,**46** go to one cell; the other **46** go to the second cell to form chromosomes of the new cell. This process continues every time.

Cell division undergoes four phases, preceded by interphase. The cell goes through this phase before cell division. It is noted that, during this phase, the nucleus is relatively large compared to nuclei in divided cells. In addition, during this phase, the cell creates large molecules of nucleic acids and proteins as preparation for division. This phase is characterized by doubling **DNA**. The centrosome also doubles during this phase.

As for the four phases, which follow the interphase, they are:

Phase one: Prophase

The chromatin network is marked into a number of chromosomes, which looks thick. It is divided into two **sister chromatids**. These sister chromatids are connected to each other at their **centromeres**. They form the subsequent chromosomes.

The centrosomes that are formed in the interphase, directed to opposite directions toward to the cell poles. The centrosomes extend astral filaments (**aster**). Spindle filaments are formed between them. The nucleolus and nuclear membrane disappear at a later stage of this phase.

Phase two: Metaphase

Chromosomes shrink and thickened at this phase. They are located at equator line of cell. Chromosomes attach to spindle filaments fibers by their centromere.

Phase Three: Anaphase

At this phase sister chromatids which formed in interphase, separate from each other and move in opposite directions of the cell. Mechanism of chromosome movement is not fully uncovered; however, there are explanationss of that:

a- Spindle filaments are thought to shrink when there is ATP; and they pull chromosomes toward the poles.

b- Spindle fibers form a path so that chromosomes slide on these threads toward the poles.

Phase Four: Telophase

The final phase starts when the chromosomes reach the opposite poles of the cell. Then the chromosomes back to their micro-filaments shape. They appear as chromatin network and nucleus division ends.

Nucleus division is followed by **cytokinesis**.

Animal cell shows difference in cytokinesis compared to plant cell. In animal cell, cell membranes constricted near cell equator line, through time, this curve and constriction increases gradually until the cell divides into two new cells, each containing a nucleus.

In plant cell, cytokinesis starts when **cell plate** formed at cell equator. This wall is secreted by cell protoplasm. Then each new cell starts forming its own cell wall from its side, this process results in two new cells.

It must be noted that time for cell division varies according to type of cell, tissue and age of the organism. Furthermore, each division phase has certain period. This period depends on events, which occur in each phase.

It is found that, division phases in human cells, prophase lasts **(30-60)** minutes, metaphase **(2-6)** minutes, anaphase **(3-15)** minutes, while telophase lasts **(30-60)** minutes. It is also noted that division time of neuron lasts **(30)** minutes during embryonic phases, while division of adult neurons is rare because adult neurons specialized in a definitive way.

Figure 1.22 mitosis (for study)

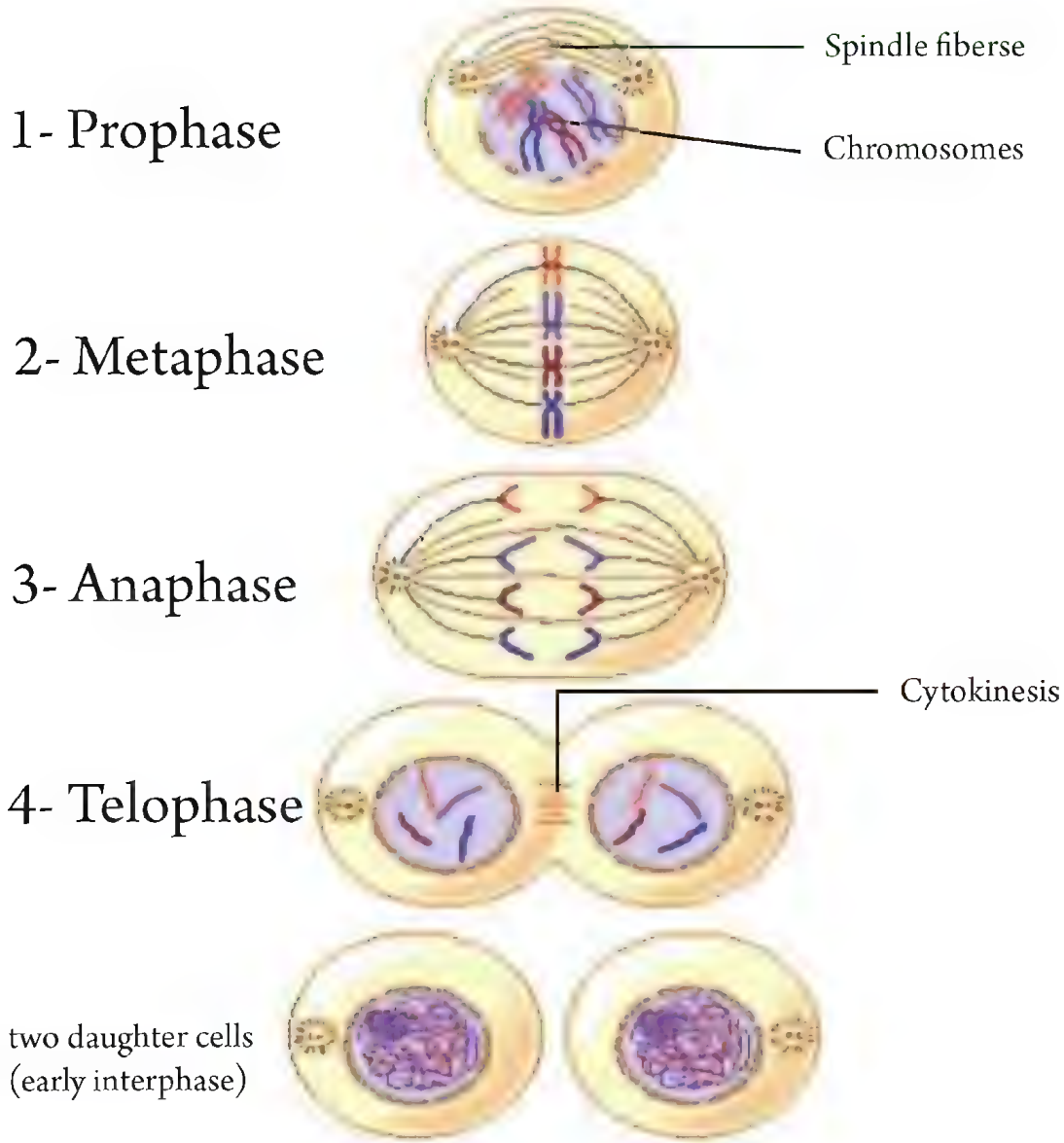


Figure 1.23 Stages of Mitosis

Meiosis

Meiosis aims to maintaining a fixed number of chromosomes for various species during succession of generations where gametes,(eggs, sperms)in animals and spores in plants are created.

Meiosis is two successive divisions of the cell. During this division, the number of chromosomes is reduced to half the number of somatic chromosomes. When two nuclei of two cells or gametes are fused to form first embryonic cell,which contains complete number of chromosomes (2n)

Meiosis is Preformed through two nuclear divisions, the first separates homologous chromosomes, and this division includes four phases:

Prophase 1
Metaphase 1
Anaphase 1
Telophase 1

As for the second division, the two chromatids of the chromosome are separated, each chromatid moves to cell pole.
The second division, is similar to first division, it includes four successive phases:

Prophase 2
Metaphase 2
Anaphase 2
Telophase 2

Below is a description of both divisions:

First Meiosis Division:

a. Prophase 1:

This phase is slow; it includes five stages with special features:

Leptotene: Chromosomes at this stage are single, long and thin filaments like beads. They look like necklace, the **DNA** (genetic material) doubled in each chromosome.

Zygotene: Homologous chromosomes align and double. Then, they bend on each other; this process is called **Synapsis.** The doubled chromosomes are called "**bivalent**", this process is distinctive in meiosis, because it does not occur in mitosis.

Pachytene: Chromosomes condense, thicken, and shorten. Each chromosome double into two clear chromatids, attached to each other via their centromeres. Each two chromatids of the same chromosome are called **sister chromatids.** At this stage, each pair of homologous chromosomes form a bundle of four chromatids, this bundle is called **Tetrad.** For example, human cell, at this stage, has 23 tetrads and 92 chromatids total.

In addition, there is an exchange of genes locations between identical chromosomes; this process is called **Crossing Over.**

Diplotene: Homologous chromosomes keepaway from each other non-sister chromatids remain attached by one or more points, these connection points are called **chiasmata**. Number and location of chiasmata differ from chromosome to another and from one cell to another. Non-sister chromatids are exchanged at each chiasmata point.

Diakinesis: This is the last stage of the prophase at which chromosomes (chromatids of homologous chromosomes) shorten and thicken more. The nucleolus and the nuclear membrane gradually degradated. Locations of chiasmata move to the far end of the chromosomes, thus, chiasmata number decrease.

b. Metaphase I

At this phase, homologous chromosomes align at cell equator in the form of bivalent chromosomes groups. centromers start to appear, and the spindle appears attached to.

c. Anaphase I

At this phase, homologous chromosomes separate and move in opposite directions toward cell poles. Chromatids of each chromosome remain attached to each other at their centromeres.

d. Telophase I

New chromosomes gather at the poles, spindle filaments often disappear at this phase. The nucleolus and nuclear membrane, which surround chromosome groups, start forming; this group is haploid because it contains half of total number of chromosomes. Nuclear division is followed by cytokinesis, as in the case of mitosis, thus, the two new cells are formed. They are ready for the second meiosis.

Second Meiosis Division:

a. Prophase 2

The number chromosomes in each nucleus in the prophase2 is half the total number of chromosomes, thus, it differs from mitosis in which the nucleus has total number of chromosomes. At this phase, the chromatids are far apart and might differ in structure because of the crossing over at pachytene stage of the prophase1.

b. Metaphase 2

At this phase, the chromosomes are located at the equator plate of the cell; it is attached by spindle filaments through their centromeres.

Each chromosome is made of two chromatids. This phase differs from metaphase 1 in that chromosomes are made of four chromatids.while chromosomes in metaphase 2 are made of two chromatids.

c. Anaphase 2

At this phase, chromatids of each chromosome split when their centrosomes are separate. Each chromatids represents a chromosome with independent nuclei moving towards one pole of the cell by spindle filaments.

d. Telophase2

At this phase, chromosomes gather at cell poles, they get longer and thinner, chromatin matter appear as fine threads (micro filaments), then the nuclear membrane and nucleoli emerge to form two new nuclei out of one original nucleus.

In some plant cells, the cell plate is formed through the spindle, and then becomes **middle lamella**, then cell wall. As for animal cells, cytoplasmic membrane is generated between the two new nuclei to separate them.

When the first and second meiosis division ends, the total outcome is four cells with haploid chromosomal group. Meiosis occurs in **testes** and **ovaries** when **gametes** are formed in animals, and it occurs in plant cells when **eggs** and **pollen** formation, although there are some differences which will be discussed later.

Mitosis	Meiosis
- One division	- Two divisions
- Two identical cells form by each division	- Four non-identical cells form by each division.
- Genetically identical cells formed	- Genetically different cells formed
- Number of chromosomes in both new cells similar to mother cell	- Number of Chromosomes in new cells is half those in mother cell
- In somatic cells	- In reproductive cells
- Division Occurs during cell life cycle continuously	- Division occurs after sexual maturity only.
- This division is used for growth, repair cells and asexual reproduction.	- Division is used in sexual reproduction and having new members of that species.

Table 1.4 A comparison between mitosis and meiosis

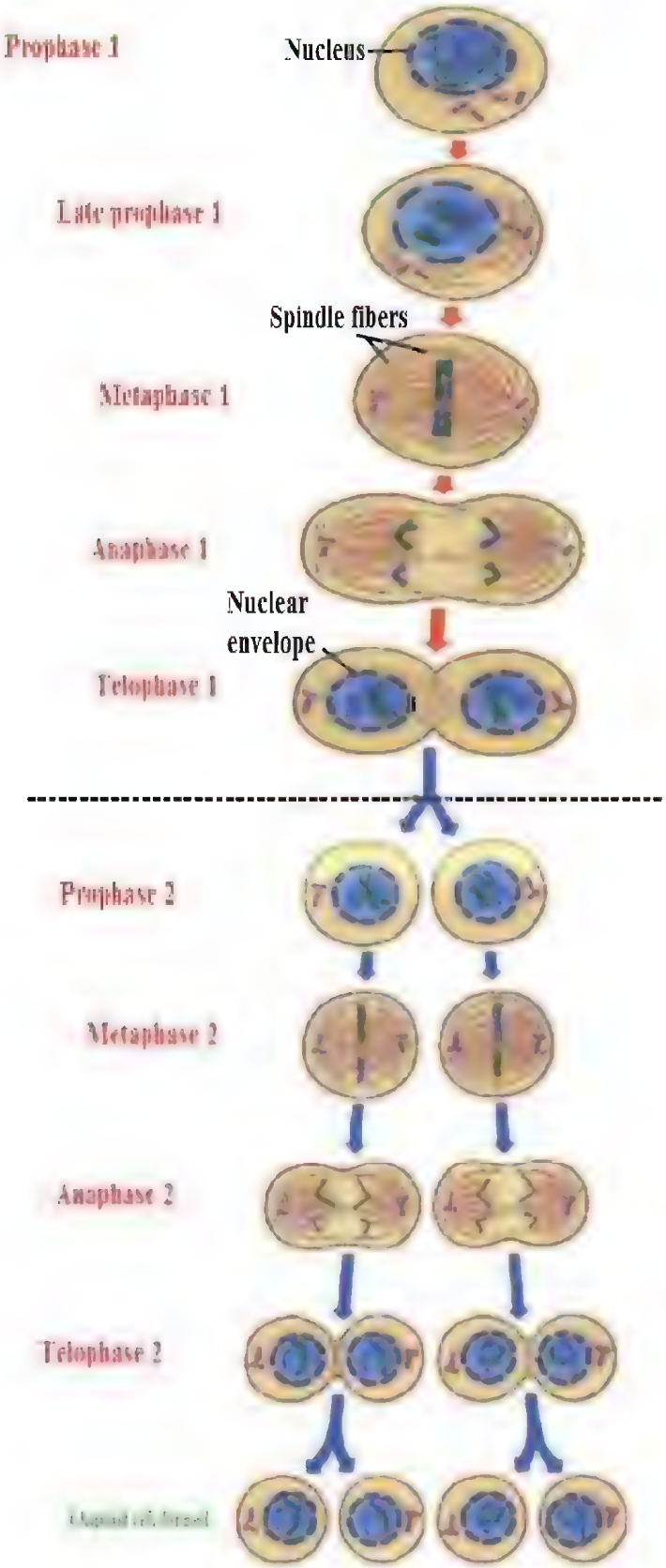


Figure 1.24 Meiosis

Review

Q.1 Write the scientific term for each of the followings.

1. ..... is a colourless liquid that fills the nucleus.
2. ..... a sphere structure inside the nucleus consists of protein and RNA.
3. ..... movement of water molecules through selectively permeable membrane according to the difference in concentration.
4. ..... operation of removing some material from cytoplasm to outside of cell.
5. ..... organelles are centers of conversion of glucose into different polymers.
6. ..... a structure located at the base of flagella or cilia in the cells which contains flagella or cilia .
7. ..... a liquid transparent material fills the internal spaces of the plastids.
8...... is the way of swallowing the remaining of the cells and germs in the blood by the white blood cells.
9...... is a group of chemical changes which happens in the cell by enzymes.
10. ..... is the operation of cell division without clear nucleic and cytoplasmic changes.

Q.2 Explain the followings.

1. There are a large number of mitochondria in the muscles.
2. There are lysosomes in the neutrophils.
3. There is an important role of centrosomes in cell division.
4. Presence of certain enzymes in the green plastids facilitate the photosynthesis.
5. The plant cell under the microscope is clear border.
6. There are cristae in mitochondria.
7. The main function of the mitochondria is cellular respiration.
8. The nuclei of cells vary in shape and this is related to the shape of the cell.
9. The cells areusually absorb some materials from external media inspite of the concentration of these materials inside the cell is higher than outside.
10. The procedure of installing carbon dioxide (CO_2) regarded as organic anabolism.

Q.3 Surround the letter which indicates the correct answer for each of the followings:

1. The first scientist who used the word (cell) is:
a- Van Leeuwenhoek b- Robert Hooke c- Robert Brown d- Theodor Schwann

2. The two scientists who set the cell theory are:
a-Matthiasand Robert Hooke b-Robert Brown and Theodor Schwann
c-Theodor Schwann and Robert Hooke d-Matthias and Theodor Schwann

3. The Endoplasmic Reticulum contribute the following except:
a-wrapping protein b-transferring materials between the cell parts
c- produce some types of fats d-store proteins and fats

4. Golgi Apparatus is called Dictyosome which is available in:
a-animal cell b-bacteria cell c-plant cell d-lymph cell

5. The location of nucleus in the embryonic cells is:
a-central b- lateral c- surrounding d-superficially

6. The movement of molecules and ions within certain media from high concentration to low concentration is called:
a- osmosis b- diffusion c- permeability d- phagocytosis

7. The organelles that plays important role in Metamorphosis in animals are:
a- centrosomes b-mitochondria c-vacuoles d- lysosomes

8. Vacuoles have the following properties except:
a-more clear in plant cells b-small in the young cells
c-It has important role in the movement of flagella and cilia d-contain cell Sap

9. The shape of the nucleus of white blood cells (leucocytes) is:
a-sphere b-oval c-clove d-irregular

10. The number of nucleoli which the nucleus of onion cell contains:
a-five b-four c-three d-two

11. The proteins in the cytoplasm of the cell forms by:
a-mitochondria b- ribosomes c-Golgi Apparatus d- lysosomes

12. The number of the chromosomes in sexual cells for Spanish butterfly are:
a-(415) b-(154) c-(190) d-(69)

13. The common way of feeding in Amoeba is:
a- pinocytosis b- phagocytosis c- parasitisim d- plasmolysis.

Q.4. Complete the following sentences:

1. Changes in the shape of some cells are due to.....
2. The main contents of eukaryotic cell determined by the following:
a..... b..... c.....
3. Golgi apparatus in the plant cell called .....
4. Endoplasmic Reticulum which lack the ribosomes describes as .....
5. There are cases the cells can be bi-nucleus as in ....., ... and .....
6. Inside the membrane of plastids there are two important structure: .....and.....
7. Cell wall consists of three layers : ...., ... and .....
8. Golgi apparatus consists of three compartments, they are; ....., ... and .....
9. Lysosomes contains large number of enzymes which is responsible for .....
10. Cell metabolism includes the process of ..... which takes place in..... and the process of ..... which performed by .....

Q.5: Answer the followings:

1. Arrange the following scientists according to the order of their discoveries:
Robert Hooke, Mathias Schleidein, Theodor Schwann, Van Leeuwenhock, Robert Brown.
1..... 2..... 3..... 4..... 5.....

2. Complete the two columns the second and third in the following table with mentioning the structure and the function of each organelle in first column:

Organelles	Structure	Function
Endoplasmic reticulum		
Golgi apparatus		
Mitochondria		
Plastids		
Lysosomes		
Plasma membrane		

3. Compare between the followings:

- Rough endoplasmic reticulum and Smooth endoplasmic reticulum.
- Semi Permeable membrane and selectively Permeable membrane.
- Centrosome and kinetosome.
- Pinocytosis and Phagocytosis.
- Telophase 1 and Telophase 2.

CHAPTER 2
TISSUES

Contents

Objectives

1- Classify the plant tissues, and determine the characteristics of each type.
2- Determine the types of vascular tissue in plant.
3- Compare between the xylem tissue and phloem tissue.
4- Classify the epithelial tissue in human.
5- Determine the location of each type of epithelial tissue.
6- Classify the connective tissue in human.
7- Define the intracellular substance .
8- Compare between proper and specialized connective tissues.
9- Define the muscular tissue.
10 - Compare between muscles tissue types.
11- Define the nervous tissue.
12- Determine the components of nervous tissue.

Introduction

Organisms differ in their body structures. Some of the organisms contain only one cell such as bacteria, certain types of algae and fungi, **Amoeba**, **Euglena** and some other types. These types of organisms are called "**Unicellular Organisms**". The bodies of some other types of organisms consist of many specialized cells; which function connectively in the form of functional tissues within the organs. These tissues function, one with another, in a great harmony to build the body of the organism. The cells of a tissue may be diverse sometimes. Also, large quantities of intercellular substance may form in some tissues.

A tissue can be defined as a group of similar cells which are all specialized to perform a certain function in addition to certain cellular resultant substances. The study of tissue is known as **histology**.

Plant Tissues

Plant tissue is a group of cells that vary in shape and size but are connected to each other to perform certain function.

The body structure of the early plants consists of one cell only as in some types of unicellular algae.This cell has the capability of performing various basic functions, such as nutrition, reproduction, etc., on the other hand the advanced plants, have a huge number of different types of cells in their bodies, which form various types of tissues perform the various plant functions.

Formation and Distribution of Plant Tissues

The various types of tissues that build the different organs of the plant are developed from the cells or the **Meristematic tissues**, which lie basically at the growing points of the roots and stems of the mature plants. These tissues are known as "**Apical Meristematic Tissues**". Meristematic tissues may also exist in other locations in the body structure of the plant such as at the bases and top points of nodes and at the base of the leaves, which are known as **Intercalary Meristematic Tissues**. There are also other tissues that occur parallel to the longitudinal axis of plant body and they are called "**Lateral Meristematic Tissues**".

The Meristematic tissues turn gradually to become permanent tissues as in the case with the tissues of the growing apex and top or lateral buds. The meristematic tissue does not usually transform entirely. A Meristematic part of this tissue, however, stays for regeneration.

Classification of Plant Tissues

The different types of tissues that build the plant body divided into four major types.

Tissue	Location	Function
Meristematic tissue	Plant parts of high cellular division	Cell division and plant growth
Ground tissue	Roots, stems and leaves in the form of the cortex, pith and pith rays	Forming internal tissue masses in roots, stems and leaves
Epidermis	Different parts of the plant	Forming the dermis which has many functions like providing plant protection, exchange of gasses and water absorption.
Vascular tissue	Different parts of the plant which contain xylem and phloem	Including phloem and xylem tissues. Their basic functions are to transport water and nutrients, storage and support

Table (2-1) Illustrates these four types of tissues in higher plants (flowering plants).

Meristematic Tissues

The undifferentiated cells of this tissue are characterized by their ability to divide actively and rapidly. This tissue occurs in the plant parts where growth takes place. This growing process leads to:

a- Elongation of roots and stems.
b- .Buds growth.
c- Thickness of roots and stems.

Generally, the meristematic tissue does not stop functioning, though its functions may stop in certain parts of the plant.

The meristematic tissue occurs in three types of tissues:

- Apical meristematic tissue.
- Lateral meristematic tissue.
- Intercalary meristematic tissue.

Tissue	Location	Function
Apical Meristematic Tissue	It is found in the tips of the roots and stems of the plant.	It gives growth in the tips of the roots and stems of the plant
Lateral Meristematic Tissue	It is found in the parts of the plants which are remote from the growing tips, i.e. the lateral side of the plant extending parallel to the outer periderm of the plant body. It consists of Vascular and cork Cambium.	The secondary growth and thickness in plants. The vascular cambium produces the secondary phloem and xylem. The cork cambium produces the periderm.
Intercalary Meristematic Tissue	It is found between the permanent tissues of the plant and is far from the growing tips as in the internodes of many monocotyledon plants.	It allows elongation in the nodes of the plant. In grasses, it is responsible for the rapid regrowth in the mature leaves.

Table (2-2) illustrates the three types of meristematic tissues with their location and function.

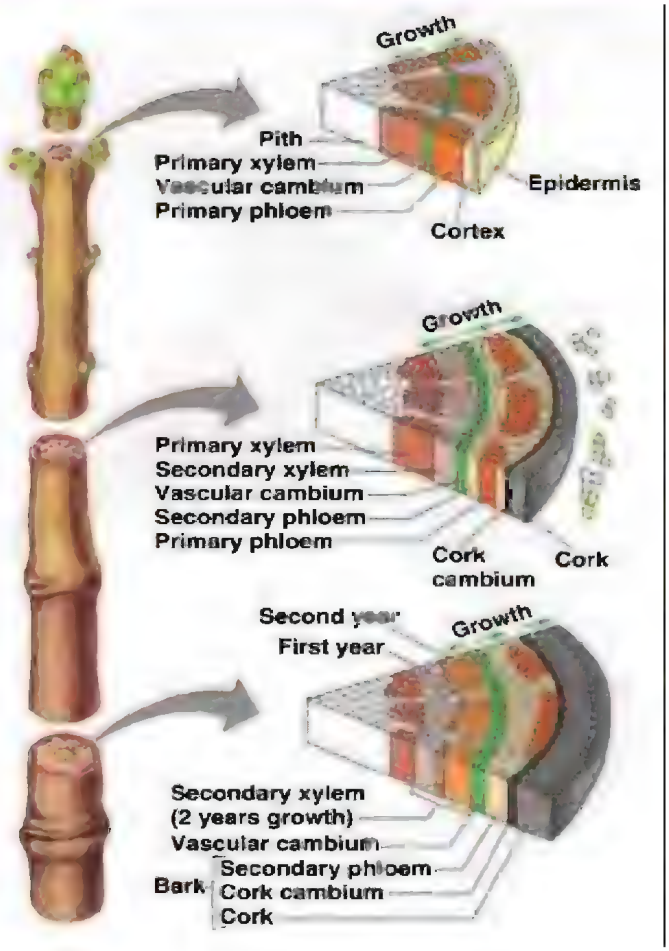


Figure 2.1 Growing levels of plant tissues (for study)

Ground Tissue

It is the tissue in which the cells differentiate to develop the permanent tissues in the plant body. It forms internal tissue masses in the roots, stems and leaves in the form of cortex, pith and pith rays. The permanent tissues in the plant body differentiate to the following types:

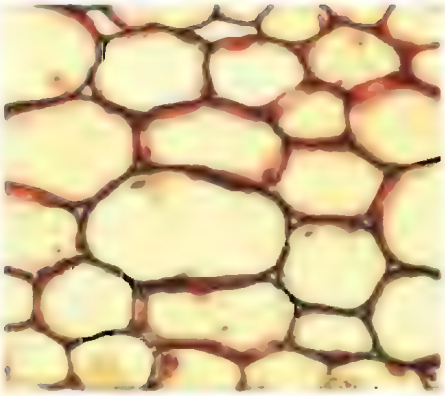


Figure 2.2 Parenchyma tissue (for study)

a- Parenchyma

The parenchyma cells are living cells. They have thin cell walls and they are often polygonal or spherical in shape due to the pressure of the neighboring cells. There are intercellular spaces between cells. The parenchyma cells may contain plastids which may be chloroplasts. Thus, the parenchyma cells are called **chlorenchyma**. Parenchyma cells have several functions, the most important of which are **ventilation, storage** and **delivery of nutrients.**

b- Collenchyma

The collenchyma tissue consists of living elongated cells with irregularly thickened walls. These tissues occur in the woody parts of plants. They also exist in the mature organs of the herbal plants.

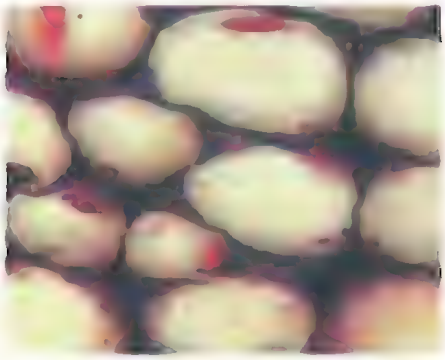


Figure 2.3 Collenchyma tissue (for study)

Collenchyma tissue is the primary supporting tissue in many stems and leaves, especially the mature ones. The collenchyma tissues rarely occur in the roots and leaves of monocotyledon plants. The main function of collenchyma tissue is to provide **structural support** and **strength**. The thick walls of the cells and their distribution assist this tissue to do these functions.

c- Sclerenchyma

Sclerenchyma tissue is composed of dead cells with extremely thick cell walls because the cells have **lignin**. The cells of the sclerenchyma tissue are highly differentiated. They differ from each other in shape, origin, composition and formation. The main function of this tissue is to provide **structural support.**

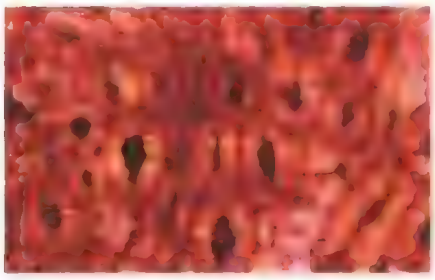


Figure 2.4 Sclerenchyma tissue (for study)

There are two types of sclerenchyma cells

a- Fibers

The cells of this type are long and cylindrical. They found individually or in bundles in the parts of the plant body which need support.

b- Sclereids

The cells are relatively short. They occur in some kinds of fruits such as pears and quinces.

Epidermis

It is the tissue that covers the plant body and forms the permanent dermal tissue. The epidermis is a single-layered group of thickened cells that covers the primary body of the plant. The epidermal cells are flat and tightly linked to each other. There are no intercellular spaces among the epidermal cells. The epidermis serves many functions; it **protects the plant body** and **regulates gas exchange** (by pairs of guarding cells) and **water absorption**.

Vascular Tissue

The vascular tissues are specialized for transporting water and nutrients throughout the body of the plant in addition to providing structural support. The existence of vascular tissues is one of the most distinguishing features of most kinds of plants. The vascular tissue includes **xylem tissue** and **phloem tissue.**

a- Xylem Tissue

The xylem tissue is derived from rectangular meristematic cells. During their development, the meristematic cells elongate and have great increase in size. When they reach maturity, they start to lose their living components and finally become dead cells.

The xylem tissue is composed of various components which differ in structure and function. These are **xylem vessels, tracheids, xylem fibers** and **parenchyma.** Xylem vessels differentiate into many types. These types vary according to the way of thickness (roughness). The tracheids are characterized by their pointed endings which distinguish them from xylem vessels. The xylem vessels and tracheids are specialized in transporting water with all the dissolved nutrients.

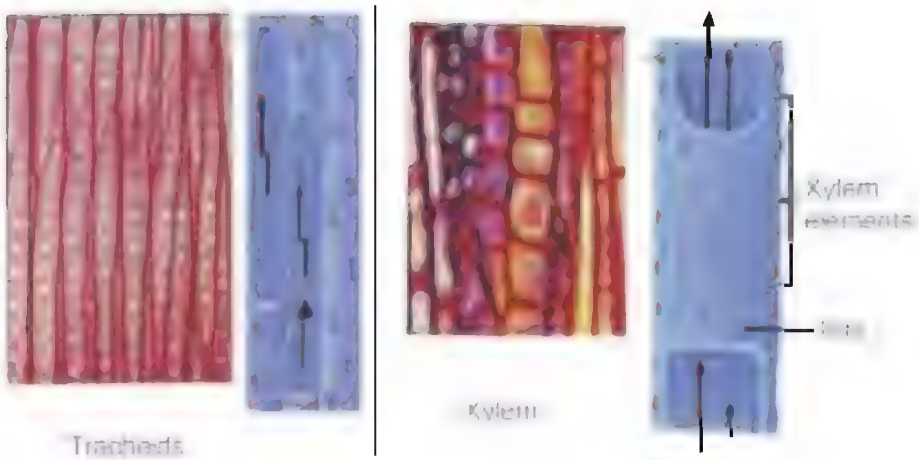


Figure 2.5 Xylem tissue and tracheids (for study)

b- Phloem Tissue

The phloem tissue is composed of several types of cells. These types of cells are **Sieve Tubes, Companion Cells, Phloem fibers** and **Phloem Parenchyma.**

All these types of phloem cells have some features in common; they are all specialized in transporting nutrients produced by the leaves, except for the fibers which have the function of providing structural support.

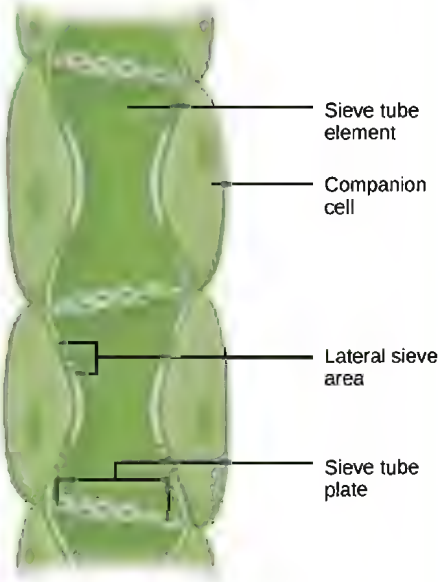


Figure 2.6 Phloem tissue

Tissue	Cell	Function
Meristematic tissue	Undifferentiated cells	Producing new cells to increase the thickness and length of the plant.
Ground tissue	Parenchyma cells Collenchyma cells Sclerenchyma cells	Photosynthesis, breathing, storage, flexible support and inflexible support.
Epidermis	Epidermal cells	Protection, regulating the exchange of gasses in stems and leaves and absorption of water and salts in roots.
Vascular tissue :		
a- Xylem	1-Xylem vessels 2-Tracheids 3-Xylem Parenchyma 4-Fibers	-Transporting water and minerals. -Storage. -Structural support.
b-Phloem	1- Sieve tubes 2-Companion cells 3-Phloem fibers 4-Phloem Parenchyma	-Transporting the organic particles throughout the plant body. -Transporting carbohydrates from/to the sieve tubes. -Structural support

Table (2.3) Types of Tissues and Cells in Plant Body

Animal Tissue

As in the plant tissue, the animal tissues are composed of a group of identical cells which are specialized in serving certain function. The cells of a tissue may sometimes differentiate and the intercellular substance may also vary from one tissue to another rather than the variance in chemical composition. Animal tissues can be grouped into four basic types:

1- Epithelial Tissues.
2- Connective Tissues.
3- Muscular Tissues.
4- Nervous Tissues.

Epithelial Tissue:

Epithelial tissue is the tissue that covers the surface of the organism that comes in contact with the external environment and lines the body cavities. Epithelial tissue forms the glands. It has the following distinctive features:

a- Epithelial tissue is represented by a continuous sheets of cells lined up in one raw or more.
b- All epithelial cells rest on **basement membrane**.
c- Epithelial cells are seperated by little intercellular space and almost have no intercellular substance. The cells endings are attached to each other at many locations by "**Cell junction**" (plasmic junction) .
The epithelial tissue is classified into two basic types according to the number of layers composing the tissue:

1- Simple Epithelial Tissue.
2- Stratified Epithelial Tissue.

FIRST: Simple Epithelial Tissues

The simple epithelial tissue is composed of one layer of epithelial cells which rest on basement membrane. It is classified into several types according to the shape of its cells:

Simple Epithelial Tissue	
1.Simple Squamous Epithelial Tissue	2.Simple Cuboidal Epithelial Tissue
3.Simple Columnar Epithelial Tissue	4.Pseudo Columnar Epithelial Tissue

1- Simple Squamous Epithelial Tissue

a- This type of epithelial tissue is composed of a single layer of flattened cells which have a polygonal appearance with a central flat nucleus.
b-The epithelial tissue covers the **inner lining of blood vessels, body cavities, lung vesicles** and **Malpighian Corpuscles**.
c-The cells of the simple squamous epithelial tissue serve the functions of **diffusion** and **filtration**.

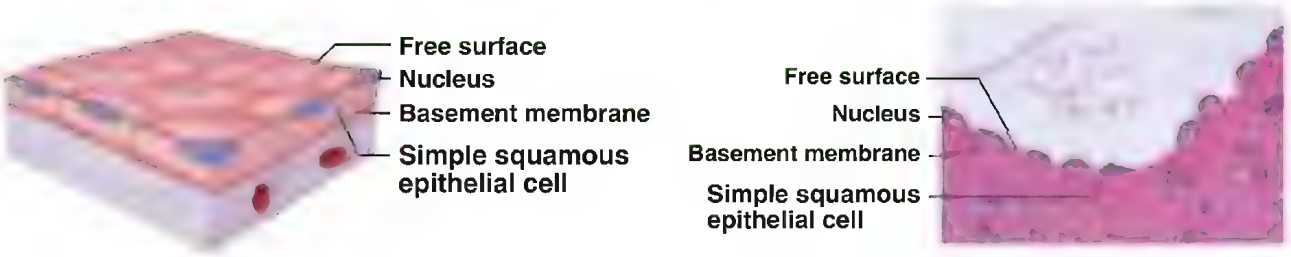


Figure 2.7 Simple squamous epithelial tissue (for study)

2-Simple Cuboidal Epithelial Tissue

a- This type of epithelial tissues is composed of a single layer of cube-like cells which have quadrangular appearance with large spherical central nuclei.
b- This tissue is found on the **inner lining of the kidney tubules** and found in some glands such as the **salivary glands**.
c- The simple cuboidal epithelial tissue performs **secretion** and **absorption**.

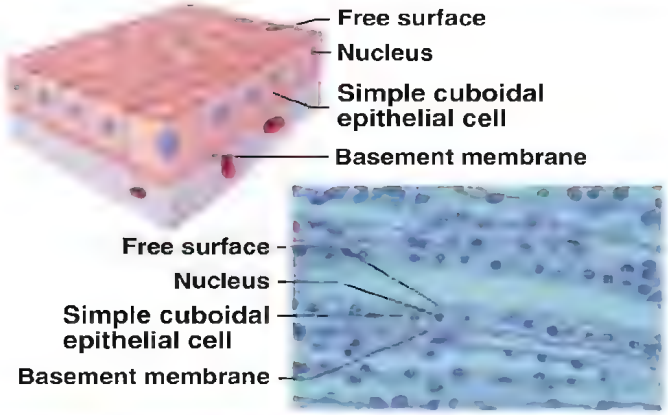


Figure 2.8 Simple Cuboidal Epithelial Tissue (for study)

3-Simple Columnar Epithelial Tissue

a- The cells of this type of epithelial tissues line up in long columns. They tend to take a rectangular appearance in their sections. The nuclei of the cells are oval-shaped and take a very close location to the basement.
b- This tissue lines the **inner lining (endothelium) of the intestines** and found in some glands.
c- The simple columnar epithelial tissue serves the functions of **protection**, **secretion** and **absorption**.

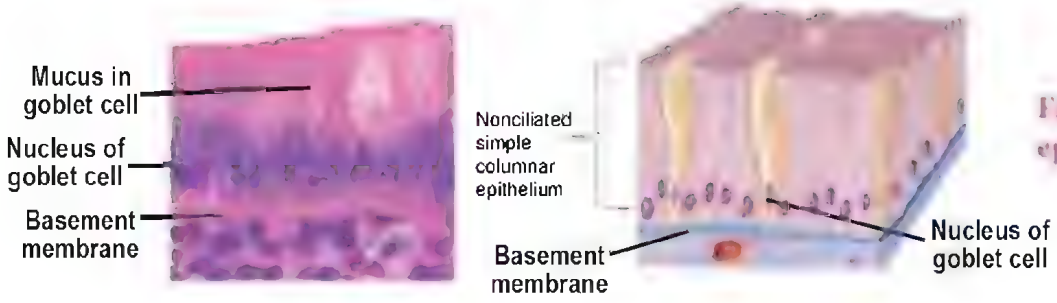


Figure 2.9 Simple columnar epithelial tissue (for study)

4-Pseudo-stratified Columnar epithelial Tissue

a-This tissue comprises more than one type of cells. The cells' nuclei are located at different levels, thus suggesting that the tissue is composed of several layers. All the cells of this tissue rest on the basement membrane and the free surface of the cells may be provided with cilia, in which case may be referred to as "**Ciliated Pseudo-stratified columnar epithelial Tissue**".

b- This type of epithelial tissues is found in the **endothelia of the trachea** and the **big ducts of salivary glands**.

c- The main functions of this tissue are **protection** and **secretion**.

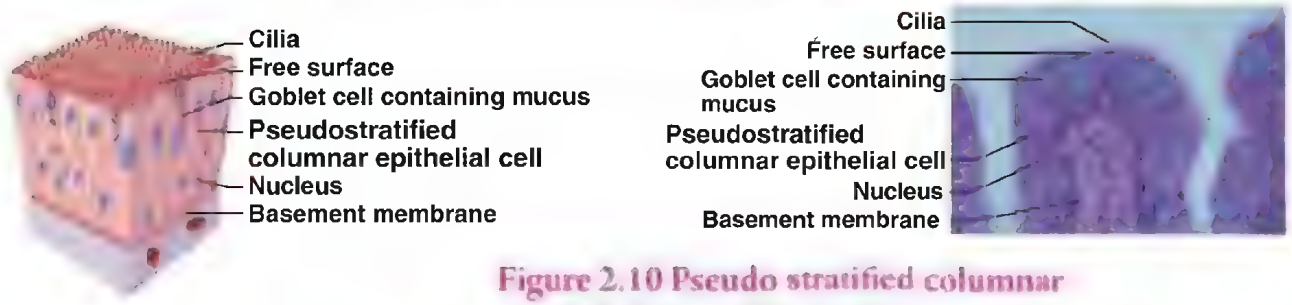


Figure 2.10 Pseudo stratified columnar epithelial tissue (for study)

Table (2-4) illustrates the types of simple epithelial tissues with the location and function of each.

Tissue	Location	Function
Simple squamous epithelial tissue	-Endothelium of blood vessels. -Endothelium of the body cavities. -Endothelium of the lung vesicles. -Endothelium of Malpighian corpuscles	-Diffusion. -Filtration.
Simple cuboidal epithelial tissue	-Endothelium of kidney tubules. found in salivary glands.	-Secretion. -Absorption.
Simple columnar epithelial tissue	-Endothelium of intestines. -Endothelium of glands.	-Protection. -Secretion. -Absorption.
Pseudo-stratified columnar epithelial tissue	-Endothelium of trachea. -Endothelium of big ducts of glands	-Protection. -Secretion.

SECOND: Stratified Epithelial Tissue

The stratified epithelial tissue comprises more than one layer of cells. It is found in areas where friction occurs, thus protecting and preserving the internal organs which it covers or lines.

Stratified Epithelial Tissue	
1. Stratified squamous epithelial tissue	2. Stratified cuboidal epithelial tissue
3. Stratified columnar epithelial tissue	4. Transitional Epithelial Tissue

1-Stratified Squamous Epithelial Tissue

a- The stratified squamous epithelial tissue is composed of more than one layer of cells. The base layer of cells is columnar or cuboidal and is rested upon the basement membrane. The cells in the middle layers are polyhedral whereas the cells in the surface layers are flattened and squamous. These cells may also be keratinized as in the case of the **outermost layer of the skin (epidermis)**
b- It forms the inner lining of the **mouth** and **esophagus**.
c- It serves the function of **protection**.

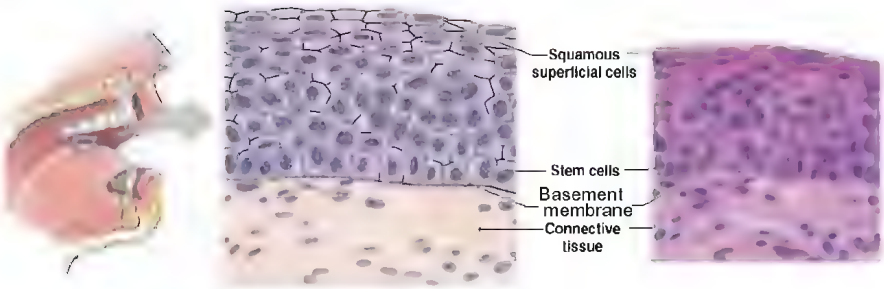


Figure 2.11 Stratified Squamous Epithelial Tissue (for study)

2-Stratified Cuboidal Epithelial Tissue

a- The cells of the surface layer of this tissue take the cuboidal appearance. The cells in the middle and basal layers are similar to the cells of the stratified squamous epithelial tissue.
b- This tissue covers the internal surface of the **sweat gland ducts** and **seminiferous tubules**.
c- The main functions of this tissue are **secretion** and **protection**.

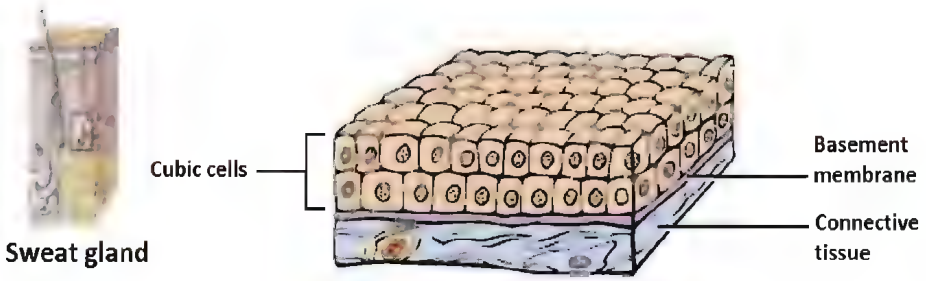


Figure 2.12 Stratified Cuboidal Epithelial Tissue (for study)

3-Stratified Columnar Epithelial Tissue

a- The surface cells of this tissue are vertical epithelial whereas the basal and middle layers cells tend to be polyhedral and usually smaller.
b- This tissue is found in the lining of male urethra.
c- The major function of this tissue is protection.

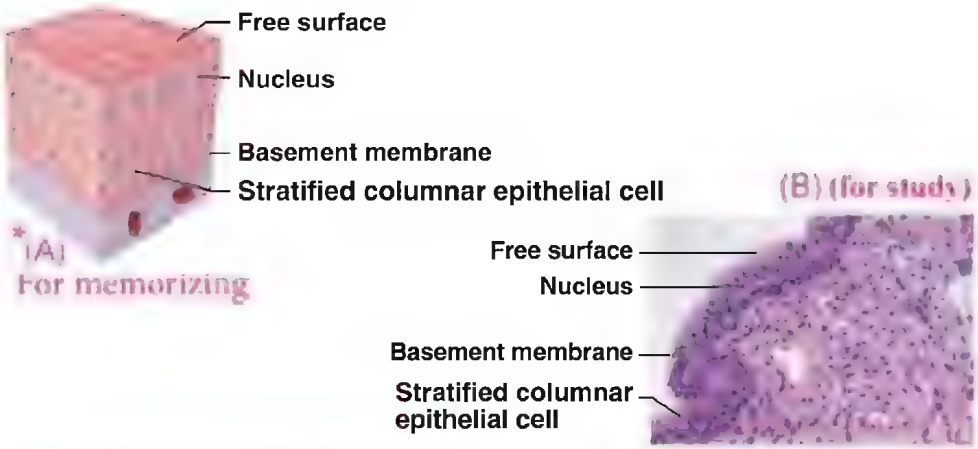


Figure 2.13 Stratified Columnar Epithelial Tissue

4-Transitional Epithelial Tissue

a- This tissue is a special stratified epithelial tissue. The surface cells of this tissue are big with a domed apex and one or two nuclei. The middle layer cells are polyhedral and the basal layer cells are cuboidal in appearance and reside on basement membrane. The cells of the transitional epithelial tissue have the ability to change their shape, thus, making the tissue extremely appropriate to line the inner walls of the organs which can contract and expand.

b- This tissue is found in the liner of the **urinary bladder, ureter** and **kidney pelvis.**
c- The major function of this tissue is **protection.** It allows the organs which it lines to contract and expand without causing any damage to the cells.

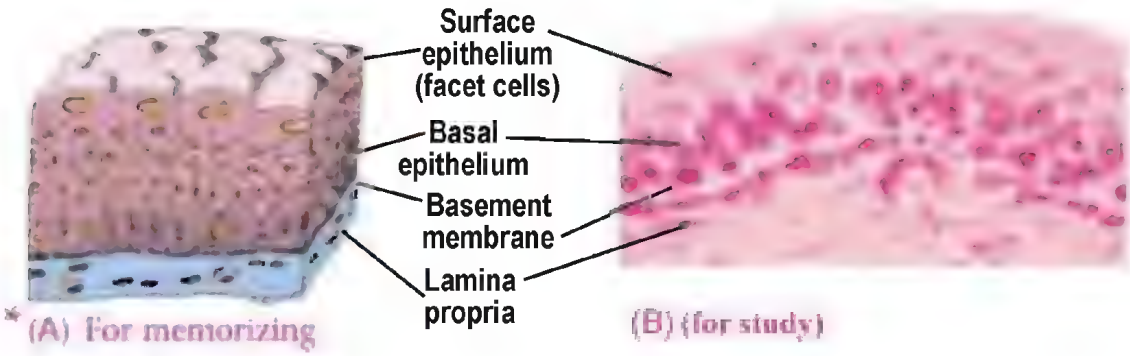


Figure 2.14 Transitional Epithelial Tissue

Tissue	Location	Function
Stratified Squamous Epithelial Tissue	-Lining of mouth. -Esophagus. -Skin epidermis.	-Protection.
Stratified Cuboidal Epithelial Tissue	-Sweat glands ducts. -Seminiferous tubules.	-Protection. -Secretion.
Stratified Columnar Epithelial Tissue	-Lining of urethra.	-Protection.
Transitional Epithelial Tissue	-Urinary bladder. - Ureter. - Kidney Pelvis.	-Protection. -Contraction and expansion of organs.

Table (2-5) illustrates the types of Stratified Epithelial Tissue, location and function.

Connective Tissues

The connective tissue is the tissue that connects and supports the different parts of the body, thus, it is referred to be as "**Supporting Tissue**". The connective tissues consist of:

a- Cells.
b- Fibers.
c- Intercellular Substance, which is called "**Matrix**".

A-Cells of Connective Tissues

The cells of the connective tissues are separate from each other. There are several types of these cells and they serve various functions. The major types of the connective tissue cells are:

1- Fibroblast

a- This type of cells is the most common type in the connective tissues. These cells are characterized with their big size and long endings of their bodies. They are flat spindle-shaped cells (fusiform). The cell has a large oval nucleus and homogeneous cytoplasm.
b- The basic function of the fibroblast is to produce all types of fibers in the connective tissues.

2- Macrophage

a- It is an amoebic cell with short stretches compared to the stretches of the fibroblast. The nucleus of this cell is not central.
b- The major function of this cell is to attack the foreign substances within the tissue, thus, its function is mainly defensive.

3- Adipose Cell

a- This type of cells is spherical in appearance and contains one fat droplet which occupies most of the cell. The cytoplasm of this cell takes the shape of a thin ring. The nucleus of the cell is flattened and located on the cell periphery.
b- The adipose cell stores fat to generate energy and maintain thermal balance of the body.

4-Mesenchymal Cell

a-This type of connective tissue cells is an undifferentiated cell with cytoplasm stretches and a central oval nucleus.
b-The main function of the mesenchymal cell lies in its ability to differentiate into any other type of cells in adult connective tissue.

5- Plasma Cell

a- Plasma cell is a relatively small spherical or oval cell with non central nucleus. The chromatin substance of the cell is arranged in a ray-like in a characteristic cartwheel or clock face arrangement. The cytoplasm of the cell is homogenous.
b- Plasma cells are responsible for secreting antibodies and playing a very important role in body protection.

6- Mast Cell

a- Mast cells are very common in the connective tissues. They are big and spherical in appearance with a small non central nucleus. The cytoplasm of the mast cells appears to be granular.

b- Mast cells contain **histamine** which plays an important role in the contraction of the smooth muscles of the pulmonary bronchioles. It also contributes to the expansion of the blood capillaries in order to increase their exuding ability. Mast cells also contain **heparin** which is an active substance to prevent blood coagulation.

In addition to the above mentioned types of cells, there are several other types of cells within the connective tissues such as the "**reticular cell**" and "**pigment cells**.

B- Connective Tissue Fibers

There are three types of fibers in the connective tissues

1. White or Collagenous Fibers
2. Yellow or Elastic Fibers
3. Reticular Fibers

Fiber	General characteristics
White or Collagenous fiber	A-It is called "White Fiber" because its color is white when it is alive condition. B-It is found in the form of bundles consisting of a number of fibers. Each fiber consists of fibrils. C-The white fiber has a mechanical importance in the connective tissues because of its resistant to tensity.
Yellow or elastic fiber	A-It is called "Yellow Fiber" because its color is yellow when it is alive condition. B-It is found in the form of single fiber not in bundles. The yellow fibers can have ramifications and they can easily stretch. They are flexible but are not as tough as the white fibers.
Reticular fiber	A-It is called "Reticular Fiber" because these fibers crosslink to form a fine network. It is a network of thin fibers. B-This fiber is found in the lymphatic nodes to which it provides a structural support.

Table (2-6) illustrates the types of connective tissue fibers with the distinctive characteristics of each.

C- Intercellular substance or matrix

The intercellular substance is found in the form of a transparent homogenous substance with no distinctive shape. It may occur as a liquid, semi-flueid, gelatinous or solid. It occupies the spaces between the cells and fibers.

D- Classification of Connective Tissues:

The connective tissues are classified according to the types of cells and the physical characteristics of the intercellular substance into:

1- Connective Tissue Proper
2- Special Connective Tissue

Each type is also sub-classified into different types

1. Connective Tissue Proper

The connective tissue proper is classified according to its cells and fibers forming it into "**Loose Connective Tissue**" and **Dense Connective Tissue**".

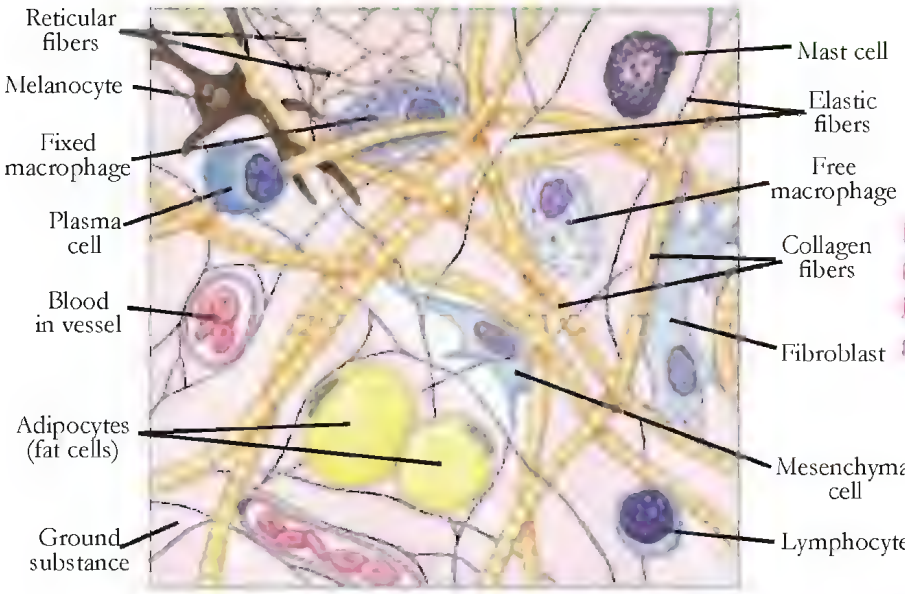


Figure 2.15 Aerolar connective tissue contain almost all kind of connective tissue cells and fibers (for study)

The loose connective tissue is classified according to the cells and fibers forming it into:

Connective Tissue Proper	
1. Areolar connective tissue	**2. Adipose connective tissue**
3.Reticular connective tissue	**4. Mesenchymal connective tissue**
5.Mucoid connective tissue	

Tissue	Location	Function
1. Areolar connective tissue; It is the most common type of connective tissues. All types of its fibers have varying densities. Various types of connective tissue cells differentiate.	a-Beneath the skin. b-Around the internal organs.	-It covers most of the body organs including the blood vessels, lymphatic vessels and nerves.
2. Adipose Connective Tissue: The fat cells prevail in the adipose connective type of tissues.	a-Beneath the skin. b-In the locations of fat storage and metabolism.	-It stores fat. -It generates energy. -It maintains the body thermal balance.

3. Reticular connective tissue: It is one of the primitive types of tissues. Reticular cells are dominant in this tissue. Its intercellular substance is liquid.	a- Lymphatic organs. b- Liver. c- Bone marrow.	-Support.
4. Mesenchymal connective tissue: It is an undifferentiated tissue. Its cells are embeded in a flueid (intracellular substance).	a- It is found in the early embryonic phase then the tissue differentiates to the various types of tissues in the adults.	-It differentiates to form various types of tissues in the body.
5. Mucoid connective tissue: It is composed of fibroblasts of a star-like appearance.embeded in a mucous gelatin substance.	-Umbilical cord.	-Support.

Table (2-7) illustrates the types of Connective tissue proper, locations and functions.

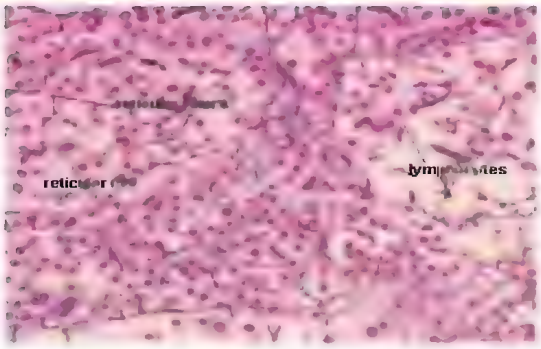


Figure 2.16 Reticular connective tissue (for study)

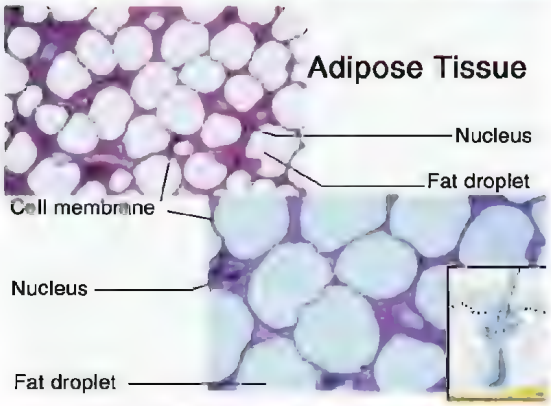


Figure 2.17 Adipose connective tissue (for study)

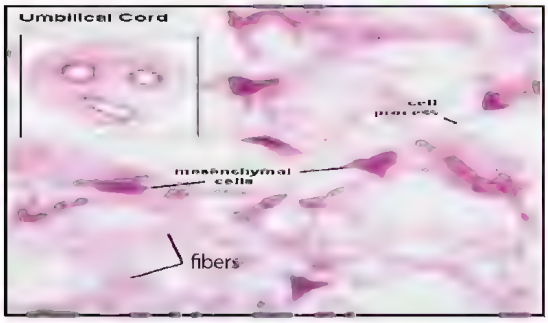


Figure 2.18 Mucoid connective tissue (for study)

The second type of the connective tissues proper is the "**Dense Connective Tissue**". It is classified according to the density of the constituent fibers into:

Dense Connective Tissue	
1-Dense Collagenous Connective Tissue	**2-Dense Elastic Connective Tissue**
Collagenous fibers are dominant in this type of tissues. The fibers in this tissue are either regular as in the tendons or irregular as in the skin dermis.	The yellow fibers are dominant in in this type of tissues. It is found in the ligaments as in the cervical ligament.

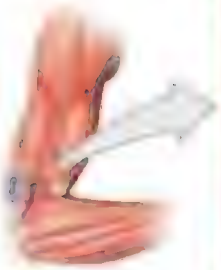
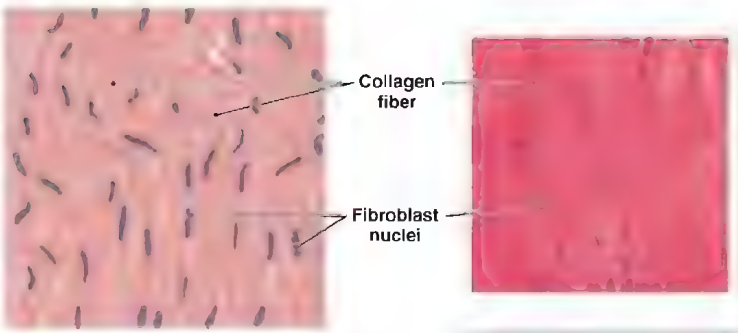
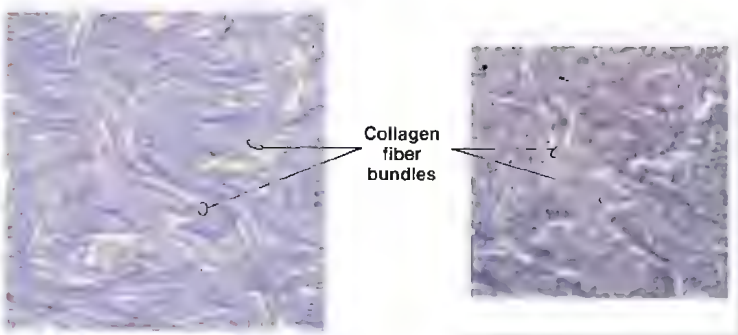


Figure 2.19 Regular dense connective tissue (for study)



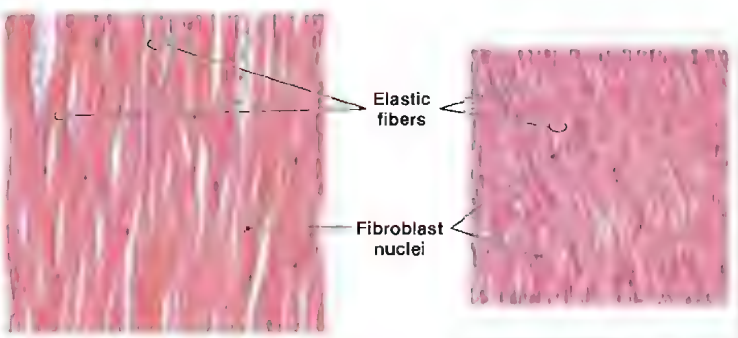
Dense regular connective tissue in a tendon from the triceps muscle

Figure 2.20 Irregular dense connective tissue (for study)



Dense irregular connective tissue from the dermis

Figure 2.21 Dense elastic connective tissue (for study)



Elastic tissue from a ligament between vertebrae

2. Special Connective Tissue

The Special Connective Tissue includes cartilage and bone which both make a structural connective tissue (they make the body structure). It also includes blood and lymph.

a- Cartilage

The cartilage tissue is characterized by its solid intercellular substance which makes it resistant to pressure and tensity. The intercellular substance contains a compound called "**Chondromucin**". The intercellular substance also includes very thin white fibers and special type of cells called "**Chondrocytes**" which are found in "**Lacunae**".

Cartilage falls into several types. It is classified according to the abundance of the fibers in the intercellular substance. It might be "**Hyaline Cartilage**" in which the intercellular substance is transparent and homogeneous due to the low fibre abundance. This type of cartilage is found in different locations throughout the body such as trachea.

Cartilage might also be "**White Fibro-Cartilage**" in which white fibers found in the discs between the vertebra in intervertebral disc.

Finally, it might be "**Elastic Cartilage**" in which the elastic or flexible fibers are dominant as in the ear pinna.

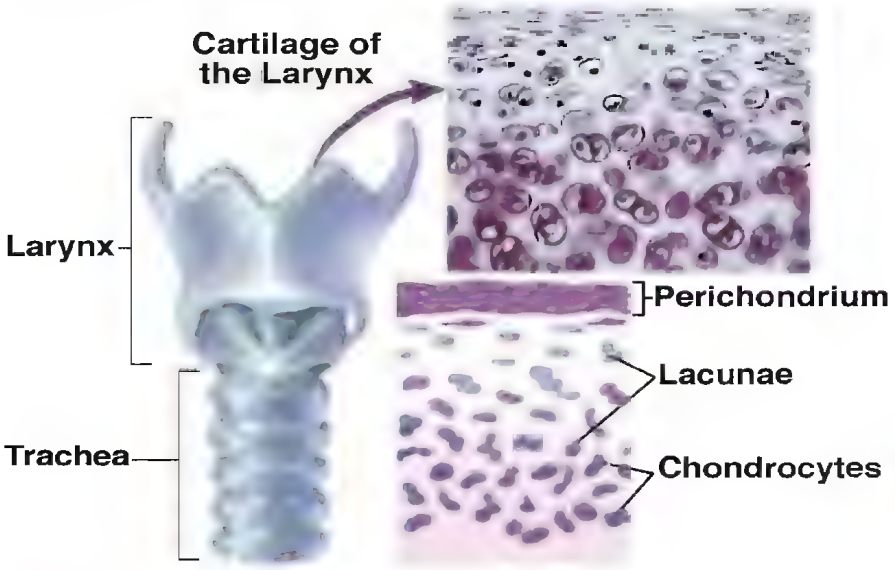


Figure 2.22 Hyaline cartilage (for study)

b- Bone

Bones represent the hardest connective tissue because its intercellular substance mostly contains calcium salts such as **calcium phosphates** and **calcium carbonates** (non-organic salts) in addition to white fibers.
Bone tissues come in two types:
1- Compact Bone
2- Spongy Bone.

As in the cartilage tissue, the bone tissue is formed of special cells called "**Osteocytes**" within lacunae, microscopic white fibers and intercellular substance

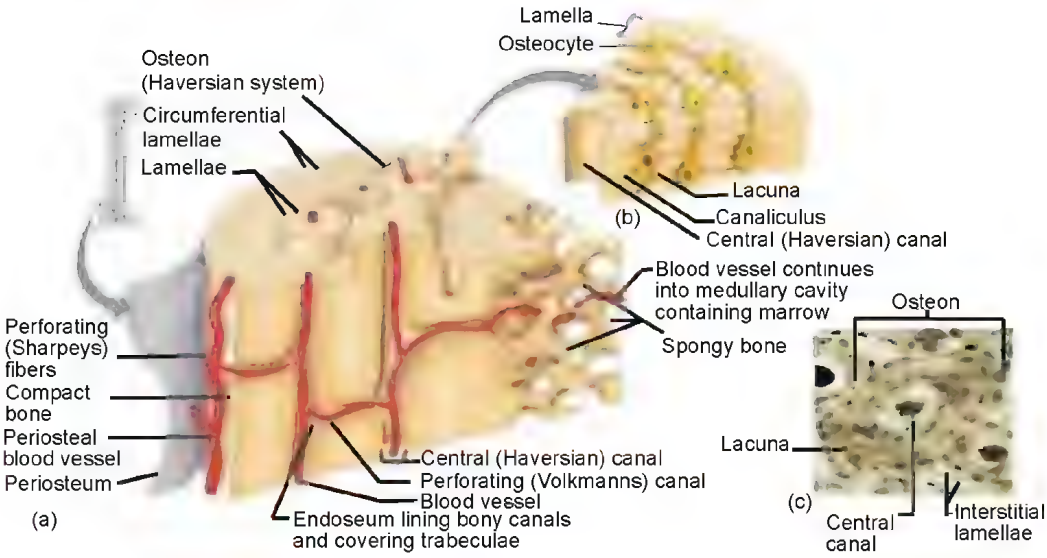


Figure 2.23 Compact bone tissue (for study)

If we study a section of the compact bone closely, we will see that its intercellular substance comes in the form of "**Bone Lamellae**" which are distributed throughout the tissue. Some of these bone lamellae take the form of peripheral lamellae which come in parallel to the outer and inner surfaces of the bone. In this case, the lamellae are called "**Peripheral Lamellae**".

Other lamellae are arranged in concentric lamellae around a central canal called "**Haversian Canal**" through which the blood vessels and nerves passed. The concentric bone lamellae and Haversian canal constitute the "**Haversian system**". The Haversian canals are connected to each other by transverse canals named "**Volkmann's Canals**". There are also intercellular lamellae which fill the spaces between haversian systems and the bone peripheral lamellae.

The concentric bone lamellae and Haversian canal constitute the "**Haversian system**".

The spongy bone tissue is different from the compact bone tissue in that the bone lamellae in the spongy bone tissue are not arranged as in the compact bone. They take the form of irregular trabecula which ramify and meet again forming vacant spaces occupied with bone marrow.

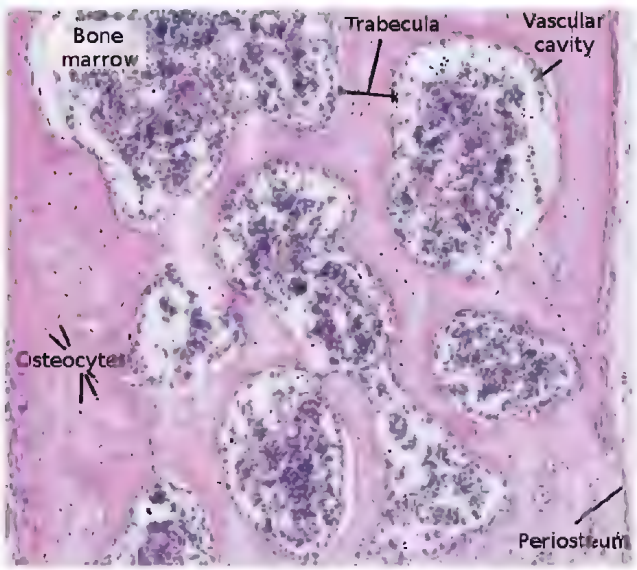


Figure 2.24 Spongy bone tissue (for study)

c- Blood

The blood is a special connective tissue that develops from embryonic mesenchymal cells. It is composed of cells, plasma and protein substances which transform into fibers when blood clotting occurs. The blood constitutes (7-8%) of the healthy adult human body weight which is about (70) kg. The human body contains (5-6) litres of blood.

First: Blood Cells

The blood cells in the human body are

A- Red Blood Cells "Erythrocytes".
B- White Blood Cells "Leucocytes".
C- Blood Platelets "Thrombocytes".

Blood is originated from the embryonic intermediary cells.

A-Red Blood Cells

The red blood cells are also called "Red Blood Corpuscles". In mammals including humans, red blood cells appear as biconcave discs with no nuclei. One exception to this prototype is the red blood cells in camels where they also lack cell nucleus but appear as oval and biconvex.

The diameter of the red blood cell in humans is (5,6 - 8,0) micrometer. The size of the red blood cells may change into smaller or bigger in some cases like sickness.

The number of the red blood cells in a mature male human is (4,000,000-6,000,000) cells per microliter. In the mature female human, the number is ranging from (3,900,000) to (5,500,000) cells per microlitter. The number of the red blood cells decrease in the case of anaemia and increase when a person goes up to high places and when being exposed to carbon monoxide.

The cytoplasm of the red blood cells contains the "Haemoglobin" which binds with oxygen to make an unstable compound called "Oxy-hemoglobin". The oxygen is dropped off when it reaches the cells and replaced with carbon dioxide forming an unstable compound called "Carboxy-hemoglobin".

The average life span of the red blood cells in humans is estimated 120 days. Every second, 2,500,000 new cells enter the blood stream to compensate an equal number of cells which got worn out during the same time. The big macrophages in the liver, spleen and red bone marrow devour the dead red cells.

The red blood cells contain hemoglobin which transport the oxygen and carbondioxide

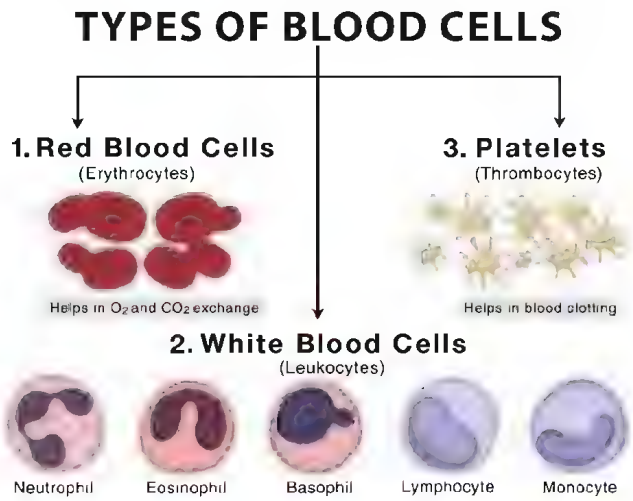


Figure 2.25 Human blood cells

B-White Blood Cells

The white blood cells are true cells in that they have nucleus and living cell contents. They also have the capability of like-amoeba moving. The number of the white blood cells in the adult human is **5000-11000** per micro litre of blood.

The ratio of the white blood cells to the red blood cells is approximately **1-700**. The number of the white blood cells in children more than that of adults. In newborn infants, there are approximately **16000** white blood cells per microlitter of blood. Many changes to the number of the white blood cells happen in special cases of sickness. The white blood cells are classified into two main groups:

First: Granular Leukocytes

The cytoplasm of this type of white blood cells contains granules with often lobulated nuclei. There are three types of granular leukocytes distinguished by their colouring ability:

1. Neutrophils:
They constitute (**40-70%**) of the total number of the white blood cells.

2. Acidophils:
These cells constitute (**1-4%**) of the total number of the white blood cells.

3. Basophils:
This type constitutes (**0.5-1%**) of the total number of the white blood cells.

Second: Non-Granular Leukocytes

The cytoplasm of this type of white blood cells does not contain granules and the cell nucleus is not lobulated. There are two types of non-granular leucocytes:

1. Lymphocytes:
They constitute (**20-45%**) of the total number of the white blood cells.

2. Monocytes:
They constitute (**4-8%**) of the total number of the white blood cells.

The white blood cells play a very important protective role against infections. They perform their functions outside the blood stream and after they enter into the loose connective tissue.

C-Blood Platelets

The blood platelets are small spherical or oval colourless discs with no nucleus. The blood platelets are found in mammals. and the lower vertebrates such as birds and amphibians in bigger spindle-like cells with nucleus.

They are called "**Thrombocytes**".
It is believed that they serve the same function of the blood platelets. The diameter of the blood platelets is **2-4** micrometer.

The average lifespan of the blood platelets in humans is **9-10** days. The big macrophages phagocyted the blood platelets in the liver, spleen and bone marrow. The blood platelets serve the function of releasing "**ThromboPlastin** " enzyme which plays a very important role in blood coagulation.

Second: Blood Plasma.

The blood plasma is the intercellular substance of the blood tissue. It is a pale yellow homogeneous liquid and can be obtained by "**Hemofiltration**". It makes up about **55%** of the total blood volume. Water makes up about **90%** of the blood plasma. The rest **10 %** includes solid substances available in the plasma as proteins, hormones, enzymes, non-organic salts, glucose etc.

The lymph is similar to the plasma in composition except that its protein content is less and its blood coagulation is slower. The clot in the lymph is soft not solid.

Lymph

The lymph is a liquid that is collected out of the tissues. It returns to the blood stream through "**Lymphatic Vessels**". The lymph is similar to the plasma in composition except that its protein content is less and its blood coagulation is slower. The clot in the lymph is soft not solid. The lymph mainly contains lymphatic cells which vary in number according to the lymphatic nodes in the passage of the lymphatic vessels through which the lymph passes.

Muscular Tissue

The muscular tissue is composed of cells called **muscle fibers**. These fibers contain Actin and Myosin filaments which gather and slide past one another to perform a certain action of movement. Muscles also serve a thermal-generating function to the body.

Muscles are classified into three types

1- Smooth Muscles.
2- Skeletal Muscles.
3- Cardiac Muscles.

1. Smooth Muscles

They are also called "**Visceral Muscles**". They are characterized by the following:

1- The cells or fibers of the smooth muscles are spindle-like with two pointed ends. They are thick in the middle and thin at the ends.
2- The muscle fibre is covered by **Sarcolemma**.
3- The cell has one central nucleus.
4- The action of the muscle is involuntary.
The smooth muscles are found in the walls of the stomach, intestines, blood vessels and other internal hollow organs.

2. Skeletal Muscles

Skeletal muscles are voluntarily controlled. They are attached to the bones through tendons. When they contract, the body part moves. They have the following distinguished characteristics:

1- The skeletal muscle fibre is a long cylindrical fibre. It may sometimes stretch along the muscle.

2- The skeletal muscle fibre is distinguished with cross-band appearance in dark and light bands. This arrangement gives the fibre a striated appearance and for this reason they are called "**Striated Muscles**".

3- The skeletal muscle fibre is covered with a special membrane called "**Muscle Membrane**". It is different from the muscle membrane which covers the smooth muscle fibre.

4- The skeletal muscle fibre is multi-nucleated. Its nuclei are peripherally positioned.

5-The skeletal muscle fibre performs its function under human control, that's why they are called "**Voluntarily Muscles**".

3- Cardiac Muscles

Heart muscles are involuntary striated muscles found in the walls of the heart only. Their contraction pumps the blood out of the heart. Their stretch allows the blood to enter the heart. The heart muscle fibre has the physical and functional characteristics of both the smooth muscle fibre and skeletal muscle fibre. It has the following features:

1- The heart muscle fibre is cylindrical in shape. It is smaller and much shorter than the skeletal muscle fibre. It is a branched fibre and its branches meet together.

2- The heart muscle fibre is distinguished with its transverse striation, very similar to that in the skeletal muscle fibre. Accordingly, the heart muscle is a striated muscle.

3- The heart muscle fibres are connected to each other at their ends in differentiated places of their plasma membranes called "**Intercalated Discs**".

4- The membrane of the heart muscle fiber is thinner than that of the skeletal muscle fibre.

5-The heart muscle fiber contains one cell nucleus. It is centrally positioned.

The blood platelets serve the function of releasing "**ThromboPlastin** " enzyme which plays a very important role in blood coagulation.

Thrombocytes serve the same function of the blood platelets.

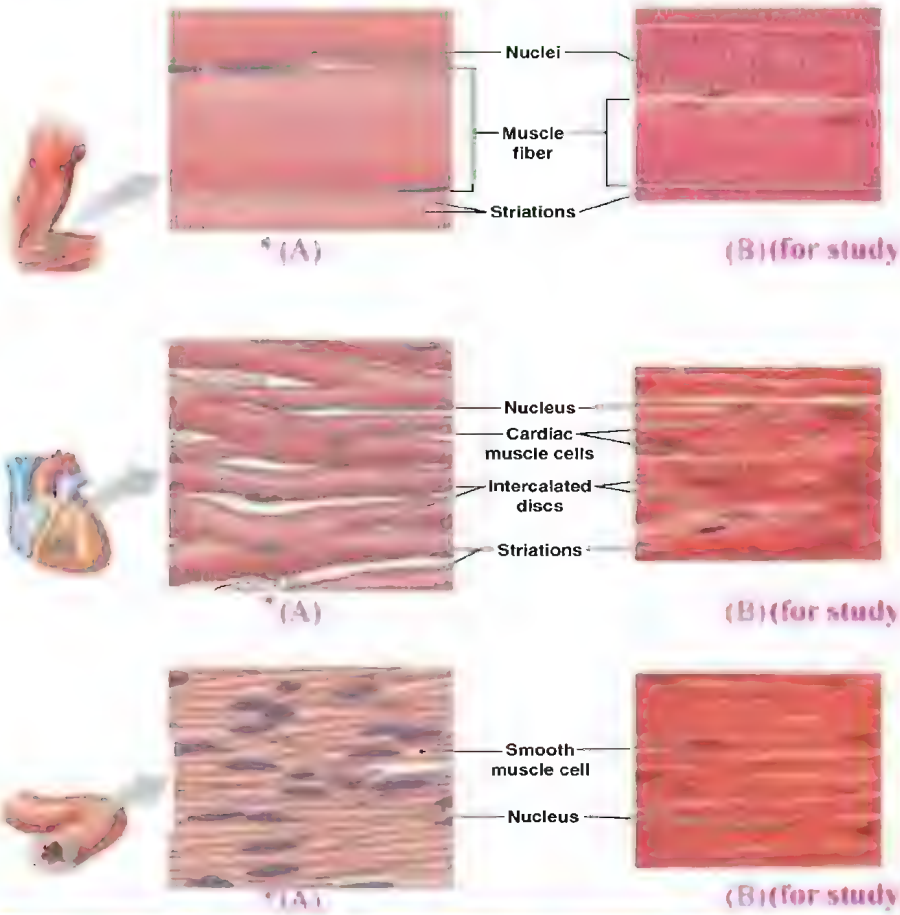


Figure 2.26 Types of muscles

Feature	Smooth muscle	Skeletal muscle	Heart muscle
1-Shape of the muscle fiber.	- Spindle-like with two pointed endings. Thick in the middle and thin at both sides.	- Cylindrical. - Long - No ramifications.	- branched. - Cylindrical. - Shorter than the skeletal muscle fiber.
2-Size of the muscle fiber.	- Small. - Short.	- Large - Long.	- Smaller than the skeletal muscle fiber.
3-Muscle striation	- Scattered. - Not striated.	- Organized. - transverse striation.	- Organized. - transverse striation.
4-Nucleus.	- One, centrally positioned	- Multi nuclei, peripherally positioned	- One, centrally positioned
5-Action	- Involuntarily	- Voluntarily	- Involuntarily

Table (2-8) presents a comparison between the different types of muscle fibers.

Nervous Tissue

The nervous tissue serves the function of propagating of nervous impulses from one part to another in the body and for long distances. It is composed of nervous cells or "**Neurons**" supported by accompanied cells within the nervous tissue. However, these cells do not perform a nervous function. They are called "**Neuroglia**".

Nervous cell (**Neuron**); *It is a specialized cell composed of three parts*

1. Cell Body

It represents the enlarged part of the neuron. It contains the cytoplasm and nucleus which has a very clear nucleolus. The cytoplasm contains the "**Neurofibrils**" and "**Nissl's Granules**" which serve as protein synthesis sites. The cell body also has the other living substances which are found in other cells.

2. Dendrites

These are extensions or thin structures that arise from the cell body. They serve the function of transmitting signals or nervous impulses to the cell body.

3. Axon

It is an extension that transports the nerve impulse away from the cell body. It may or may not be covered with a medullary membrane. It is usually single and long.
The nervous cells (**Neurons**) are usually classified according to the number of the extensions that arise from the cell body into:

1-Monopolar Neuron; the cell body of the monopolar neuron is oval or spherical with only one extension.

2-Bipolar Neuron; the cell body is spindle-like with two extensions.

3-Pseudo unipolar Neuron: one polar seperates near the cell base into axon and dendrite.

4-Multipolar Neuron; the cell body is star-like with multi extensions.

Neuroglia

They form the largest part of the nervous tissue. They constitute (**1-50**) of the tissue, i.e. each neuron has (**50**) cell counterparts of the Neuroglia. They occupy more than half of the brain volume. Their main function is to provide support for the neurons. They also phagocytes bacteria and cellular debrise.

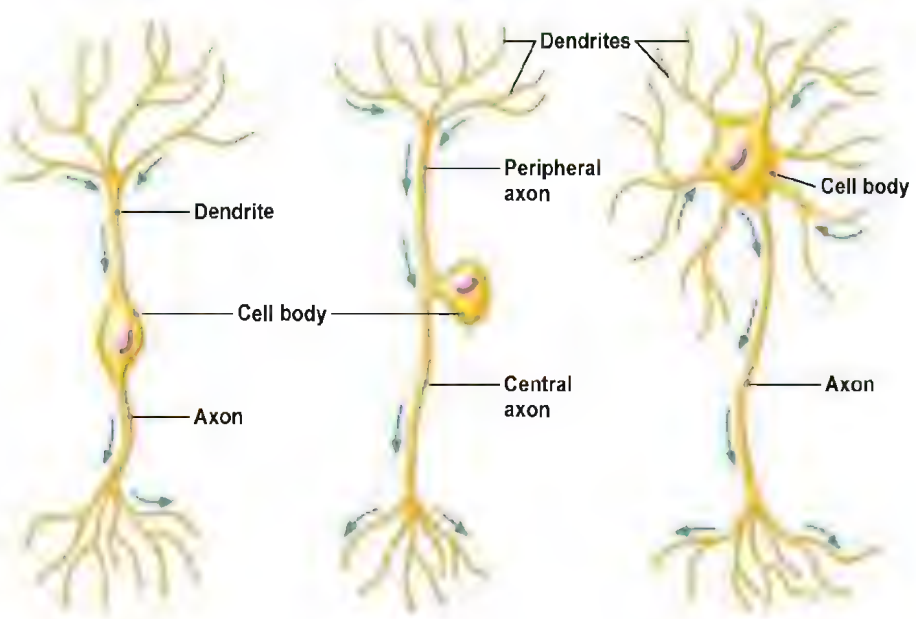


Figure 2. 17 Types of neurons and their structure

Review

Q. 1 Write the scientific term for each of the following statements:

1. .....the meristematic tissues which are found at the growing tips of the stems and roots of higher plants.
2. ..... the meristematic tissues which are available at the base of the leaf blade.
3. ..... the tissue in which the cells differentiate to form the permanent tissue in the body plant.
4. ..... the parenchyma cells which contain the plastids.
5. ..... one of the two types of the sclerenchyma cells found in some fruits like pears.
6. ..... one of the connective tissue cells. It has an amoeba appearance and its nuclei not centrally positioned.
7. ..... a type of the connective tissue fibers. It occurs individually and it is flexible and extendable.
8. ..... spindle-like cells that are found in the blood of birds and amphibians. They are counterparts of the blood platelets in mammals.
9. ..... an enzyme released by the blood platelets. It plays an important role in blood clotting (coagulation).
10. ..... the cells that form the largest part of the brain. They constitute more than half of the brain volume.

Q. 2 Explain the following scientific facts?

1. The parenchyma tissue cells are often spherical or polygonal in shape.
2. Why is it called pseudo-stratified columnar epithelial tissue?
3. Transitional epithelial tissue is appropriate to the extendible and contactable body organs.
4. The existence of histamine in the mast cells of the connective tissue.
5. The connective tissues are described as supportive tissues.
6. The bone is the hardest connective tissue in human body.
7. The skeletal muscles are called striated muscles.

Q.3 Surround the letter of the correct choice:

1. The meristematic tissues that are found at the bases and tips of internodes are:
a-Apical. b- Intercalary c- Lateral. d- Peripheral.

2. The plant tissue which cells are dead and have thick walls are:
a- Collenchyma. b- Parenchyma. c- Sclerenchyma. d- Mesenchyma.

3. The tissue that is found in the trachea lining is:
a- Simple Squamous Epithelial Tissue. b- Pseudo-stratified Columnar Epithelial Tissue.
c- Simple Columnar Epithelial Tissue. d- Simple Cuboidal Epithelial Tissue.

4. The simple cuboidal epithelial tissue is found in the lining of:
a- Blood vessels. b- Alveoli. c- Kidney tubules. d- Glands.

5. The cell responsible for developing all types of fibers in the connective tissue is:
a- Plasma Cell. b- Macrophage. c- Mesenchymal Cell. d- Fibroblast.

6. Plasma cell is a type of the connective tissue cells. It serves the function of.
a- phagocytes alien bodies. b- Secreting antibodies.
c- Maintaining thermal balance. d- Differentiating into any other type of connective tissue cells.

7. The type of the loose connective tissue that is found in the liver is.
a- Reticular b- Mesenchymal. c- Mucoid. d- Adipose.

8. The type of the cartilage found in the ear pinna is :
a- Hyaline Cartilage b- White Fibro - Cartilage c- Elastic Cartilage d- Mucoid

9. The number of the red blood cells in human increases above the normal level when:
a- affected with Anaemia b-living in high places c- living near water d- affected with cancer

10. The red blood cells life span in human estimated by:
a-(130)days. b-(120)days. c-(112)days. d-(140)days.

11. The ratio of plasma in blood is:
a-(55)%. b-(50)%. c-(90)%. d-(95)%.

12. The muscles that are spindle-like with two pointed ends and become thick in the middle part are called:.
a- Smooth b- Skeletal c- cardiac d- Striated

Q. 4 Complete the following sentences:

1. Xylem tissue is composed of number of components which differ in structure and function. These components are:
a- ..... b- ..... c- ..... d- .....
2. The tissue that covers the lining of the urethra is called ..... .
3. The cells of the Stratified cuboidal epithelial tissue are found in .....
4. The connective tissues are composed of: a- ..... b- ..... c-.....
5. The Connective Tissue Proper is classified according to the density of contents to: ..... and .....
6. The Concentric Bone Lamellae and the ..... form a system called "..... ".
7. The oxygen combines with hemoglobin to form a compound called .....
8. There are three types of Granular Leucocytes: 1- ..... 2- ..... 3-..... .

Q. 5 Compare between the following:

1. The meristematic tissue and the vascular Tissue in terms of location and function.
2. The ground tissue and the epidermis in terms of location and function.
3. The xylem tissue and the phloem tissue in terms of components and function.
4. The compact bone and the spongy bone.

Q. 6 Match group 1 and group 2. Put the number of the correct answer from group 2 between the brackets:

Group 1	Group 2
Simple Squamous Epithelial Tissue ( )	1- Support.
Reticular Connective Tissue ( )	2- Secretion and Prevalence.
Simple Columnar Epithelial Tissue ( )	3- Protection and Secretion.
Simple Cuboidal Epithelial Tissue ( )	4- Support and Absorption.
Stratified Squamous Epithelial Tissue (	5- Prevalence and Filtering.
Pseudo-stratified Columnar Epithelial Tissue ( )	6- Protection.
	7- Secretion and Absorption.
	8- Protection, Secretion and Absorption.

CHAPTER 3
REPRODUCTION

Contents

Objectives

1-Define the concept of reproduction.

2-Define the sexual and non sexual reproduction and compare between both.

3- Explain the reproduction in animals.

4- Describe the reproduction mechanism in bacteria.

5- Explain the sexual and non sexual reproduction in chlamydomonas.

6-Numerate the steps of both sexual and non sexual reproduction in Paramecium.

7- Explain how Euglena reproduce.

8- Explain the reproduction in bread black mold.

9- Define the concept "Alternation of generations".

10- Explain the reproduction in Ferns and Mosses.

11- Explain the structure of flower as the specialized organ of reproduction in flowering plants.

12- Compare between monocots and dicots.

13- Explain the mechanism of seed formation.

14- Understand the concept of vegetative reproduction in plants.

15- Explain the reproduction in : Hydra, Planaria and earthworm .

16- Identify the reproductive system composition in insects.

17- Identify the reproductive system organs in frog.

18- Identify the male and female reproductive system organs in human.

19- Explain Parthenogensis and Hermaphroditisim.

Introduction

All organisms must produce new individuals similar to itself to preserve the species.

Reproduction means production of new individuals approximately similar to parents. Sexual reproduction which is performed by most of multi-cellular animals is more complecated from asexual reproduction which primitive organisms perform. But both types of reproduction have two main states:

1- Collection of pure substances from environment and transmission to new generation.
2- Transmission of genetic material (**DNA**) to next generation.

Reproduction and its role in preserving species

Reproduction is different from other life activities like digestion, respiration, circulation and excretion since these activities are important for organisms to survive. Unlike this organisms don't need reproduction to survive and may not be able to reproduce or have no complete organs for reproduction but have a healthy body for continuity of their lives.

Organisms don't need reproduction to survive but they need it for continuity of their generations.

An organism without functional reproductive organ can complete continuity of its generation and disappear.

In some kinds of animal populations reproduction performed by participation of only a few number of organisms. For instance; in a bee hive most of bees are sterile female members and they have no role in reproduction. But the drones (male bee) have ability of reproduction and they are less in number. There is only one female that able to do reproduction, the queen.

Types of reproduction

There are two main types of reproduction; asexual reproduction and sexual reproduction:

1. Asexual reproduction

Some organisms can have new organisms similar to them by broking and change a part of body into a new independent organism. This type of reproduction can produce one organism or more.

2. Sexual reproduction

Most of plants and large amount of animals are distinguished by having male and female members. The males are able to produce **sperms** while females are able to produce eggs (**Ova**).

These organisms are different from each other in their anatomy, physical features and structure of reproductive organs.

Sexual reproduction is performed by union of male and female reproductive cells by passing through a process called **fertilization**.

Sexual reproduction passes through two main steps.

1- In first step cell undergo meiosis, the number of chromosomes reduced and resulted cells receive half of the original number of chromosomes.

2- In second step two gametes are unite in a process called **fertilization** to form a cell called **zygote** with total number of chromosomes (**2n**). Then this embryonic cell (zygote) grows into a new organism by series of mitotic divisions.

1.Spermatogenesis

Sperms are formed in testis which consist of a large number of **seminiferous tubules**. Cells located at the periphery of these tubules, which are first step in this process are called as **spermatogonia** and they are diploid (**2n**). Each spermatogonium passes through a period of growth after a series of divisions and forms **primary spermatocyte**.

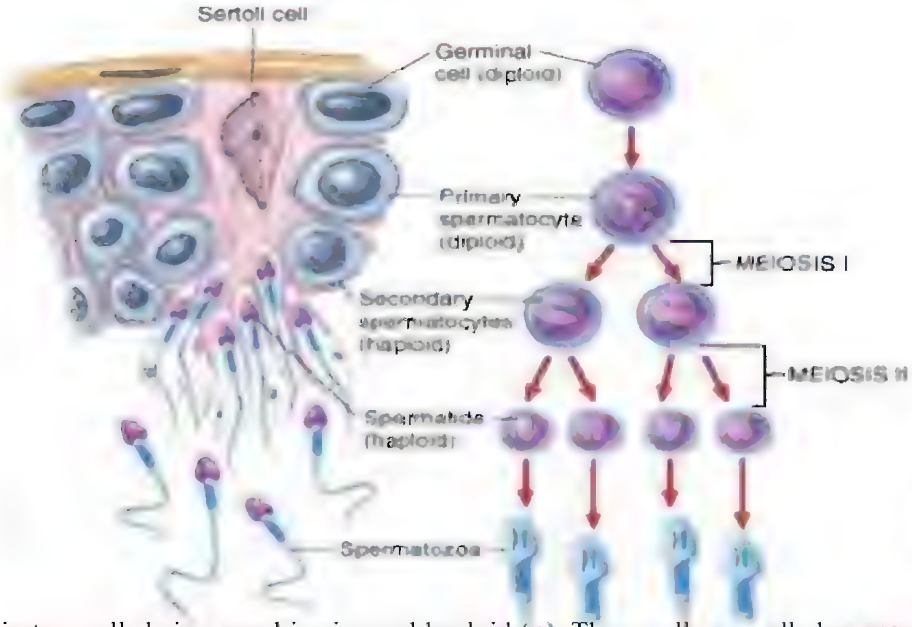


Figure 3.1 Stages of sperm formation

in two cells being equal in size and haploid (**n**). These cells are called as **secondary spermatocyte.** And each of them passes through the second division of meiosis and haploid (**n**) cells which equal in size are formed. Each of these cells called as **spermatid**. And each spermatid undergoes changes in shape and structure to form **mature sperm**.

2. Oogenesis

Reproductive cells (germ cells) in female are formed in **ovary**. The cells in ovary undergo equal mitotic division to form a group of cells called **oogonia**. Oogonia undergo normal division to increase in number (**2n**).
These cells pass through a period of growth to increase in volume and form diploid cells (**2n**) called **Primary oocytes**. There are many cells small in size which form a layer around primary oocyte called as **follicle cells**. Primary oocyte and periphery positioned follicle cells together forms **ovarian follicle**.

Primary oocyte and periphery positioned follicle cells together forms **ovarian follicle**.

Primary oocyte undergoes first division of meiosis and result in two cells being unequal in size are formed, due to unequal cytoplasmic division. And these cells are haploid (**n**). The big sized cell called as **secondary oocyte** while the small sized cell called as **first polar body.**

Secondary oocytes pass through second division of meiosis and form two cells unequal in size. Big sized cell (**Ooblast**) passes through a period of growth to form mature egg (**ovum**). But small sized cell called as **secondary polar body** (**n**) and has half number of chromosomes.

Remember
As a result of oogenesis one mature egg and three second polar bodies are formed.

First polar body undergoes second division of meiosis and forms two secondary polar bodies. As a result one mature egg and three second polar bodies are formed.

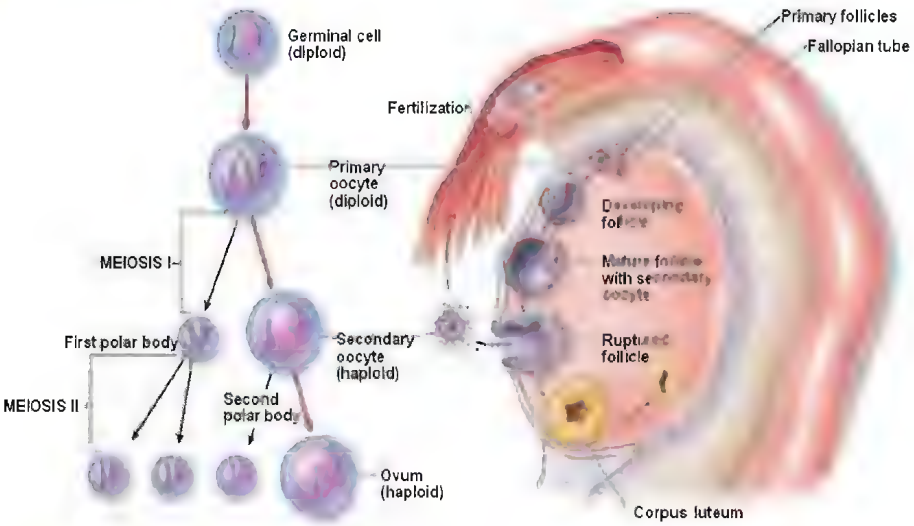


Figure 3.2 Stages of egg formation (for study)

Reproduction in Viruses

Viruses are tiny structures which can be seen only by electron microscope. They represent a connecting link between living organisms and non-living things.
Viruses cause diseases in human, animals and plants.

They are able to grow and reproduce inside the living cells of other organisms but cannot survive in external environment. This is due to viruses have no cellular mechanism to reproduce independently

Reproduction

Information about virus reproduction is obtained by observing a type of virus, attacking a kind of bacteria called "**Escherichia coli**". This type of viruses which attack bacteria called as **bacteriophage**. Viruses can reproduce by two types of interacted cycles the **lytic cycle** or **lysogenic cycle**:A

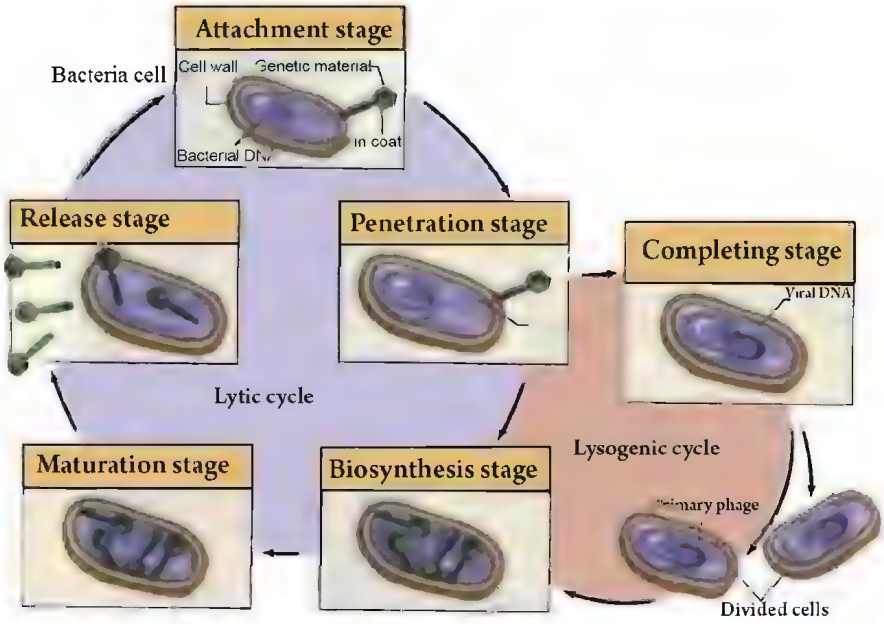


Figure 3.3 Reproduction in viruses

A-Lytic cycle:

1. Attachment stage

When the virus becomes in contact with the bacteria, the fibre exist in the tail stick to special positions on the cellular wall of the host.

2. Penetration stage

The enzyme found in the tail decomposes the cell wall of bacteria in the region of adhesion. The nucleic acid of the virus (**DNA**) is injected into the host cell.

3. Biosynthesis stage

When viral **DNA** enter to bacteria, it transcripts **mRNA** necessary for the construction of enzymes for degradation of **DNA** and **mRNA** of bacteria then the cellular mechanism of bacteria produces of proteins and releases energy under the control of viral **DNA**. Viral **DNA** directs the mechanism of the host for the formation of new nucleic acids (**DNA**) and new viral proteins.

4. Maturation stage.

Molecules of protein are organized in order to form protein covers around new strips of the viral nucleic acid; as a result, **100-200** new viruses are made.

5. Release stage

New viruses cause the decomposition of the host bacterial cell. These viruses are released in order to infect other disinfected bacteria. This process completely takes about **25** minutes.

A prophage is a phage (viral) genome inserted and integrated into the circular bacterial DNA chromosome or existing as an extrachromosomal plasmid

B-Lysogenic cycle

In lysogenic cycle attachment and penetration stages occur as in lytic cycle. Then nucleic acids of virus (**DNA**) incorporate with nucleic acid of bacteria (**DNA**) without breaking nucleic acid of bacteria and viral DNA called as **prophage**. And prophage is duplicated by reproduction of bacteria.

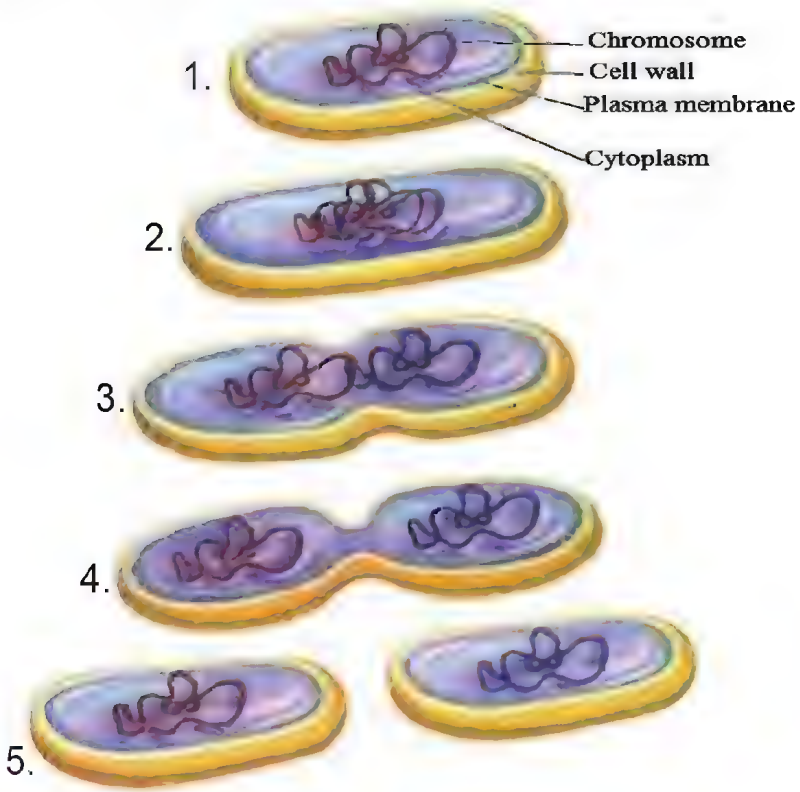
Reproduction in Monera

Monera includes **bacteria** and **cyanobacteria**, it reproduces sexually and asexually, we will focus on reproduction in bacteria as an example of reproduction in monera.

A- Asexual reproduction in bacteria

Bacteria reproduce asexually by **binary fission**.
This can be summarized as follows

1- The chromosome of the bacteria sticks to the **plasma membrane** in a certain position and that means the bacteria cell is ready for the division.
2- The bacteria cell gets ready for binary fission by expanding cell membrane and plasma membrane .
3- The division of **DNA** produces two identical chromosomes and at the same time the cell membrane and plasma membrane starts to stretch.
4- As a result of this stretch the two chromosomes split in two different directions within the cell at the same time, the cytoplasm spreads and the cell stretch will increase.
5- The cell divides to produce two identical cells.



* **Figure 3.4 Reproduction in bacteria (binary fission)**

B- Sexual reproduction in bacteria

Bacteria reproduce sexually by **conjugation** which occurs between different strains of bacteria. Scientists found that when two different strains of colon bacteria **(E-coli)** are mixed within one transplant media, a new strain appears which functionality differs from the two original strains that have been mixed. A type of genetic unity take place between two cells. They represented by **recombination**.

Conjugation within bacteria is processed in the following steps.

1- First conjugation happens between two cells. The first cell is called **donor cell**, this contain **fertility factor**, represented by the **DNA** particles in cytoplasm of the donor cell. These cells also contain sex pili on its surface. This structures make this cell as the male donor cell. The second cell **recipient cell** does not contain fertility factor or sex pili and represents the female cell.

2- When sex pili touch the surface of recipient cell, it transforms into a conjugation bridge which binds the protoplasm of two bacterial cells.

3- One of the **DNA** strand of the fertility factor broke in a certain point and extend to transfer the recipient cell.

4- This broken **DNA** gathers with a part of the cytoplasm of the donor cell moves to the recipient cell through the conjugation bridge. **DNA** strand replicate itself and become a complete double strand of **DNA**.

The donor cell remain as it was in terms of the genetic material because the broken **DNA** strand of fertility factor will be replicated in the donor cell. At the end of conjugation both cells posses the fertility factor or **plasmid**. This kind of sexually reproduction is not an ordinary one, because of new bacteria does not receive a complete collection of genes from both of the original cells.

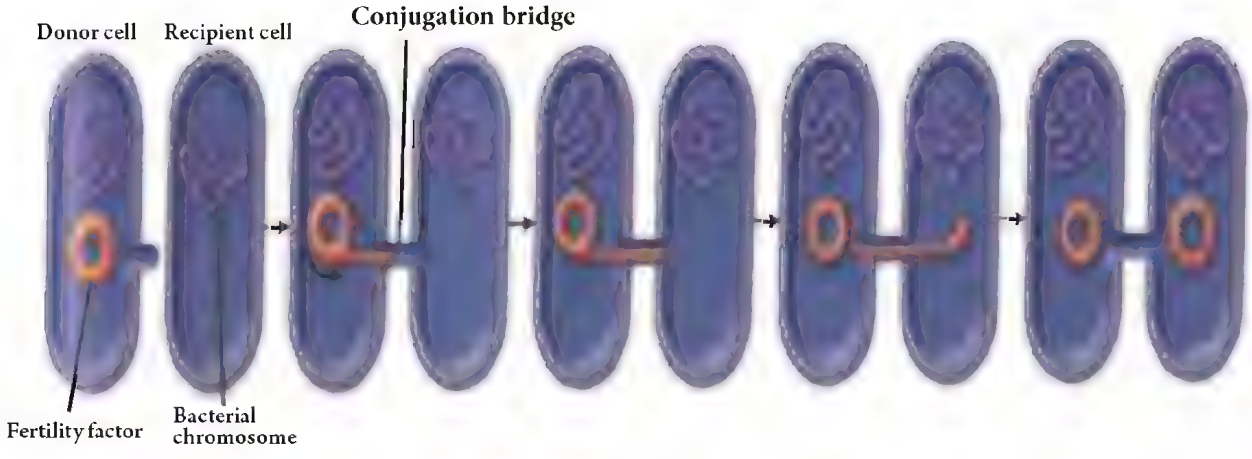


Figure 3.5 Conjugation in bacteria (E-coli)

Reproduction in Protista

Protista includes various types of unicellular organisms. We will study reproduction of **Chlamydomonas**, **Euglena** and **Paramecium** as example.

Chlamydomonas, euglena and paramecium are examples for protists.

Reproduction in Chlamydomonas

Chlamydomonas is a unicellular organism from green algae. It lives in lakes and reservoirs. The special characters of this organism is having two flagella. It is surrounded by a thick cellulose wall and contains a green coloured plastid which has a cup shape. Chlamydomonas reproduce sexually and asexually.

1) Asexually reproduction

Asexual reproduction begins by formation of(2 – 8) or 16 **zoospores** which are able to move and swim in water. Division takes place within the cellulose wall of the original cell. The spores release after breaking of cellulose of original cell wall of mother cell. And they grow into independent individuals which cam swim in water.

2) Sexually reproduction

Sexually reproduction in Chlamydomonas usually happens when the living conditions are poor as follows:

1. Chlamydomonas which has haploid number of chromosomes undergoes series of normal divisions. This will give 16 – 32 individuals within the cellulose cell wall. These individuals similar to the mother chlamydomonas but they are much smaller than it and these are called as **isogametes**.

2. The cell wall of the mother cell will be shuttered and isogametes release into the water. And they unite with other isogametes from another strain which are formed in the same way.

3. Zygote will be formed as a result of union of isogametes.

4. This zygote has pair of chromosomes (**2n**) this structure swim in water for a while and then it loses its flagella. It surrounded by a thick cellulose wall in order to resist against unsuitable environmental conditions and called as **zygospore**.

5. The zygospore re-activated in the suitable conditions, it divides by meiosis to make four haploid zoospores (**n**).

6. The surrounding wall split and then the new four zoospores which are similar to the mother cell in a way grow and behave like grown independent organisms.

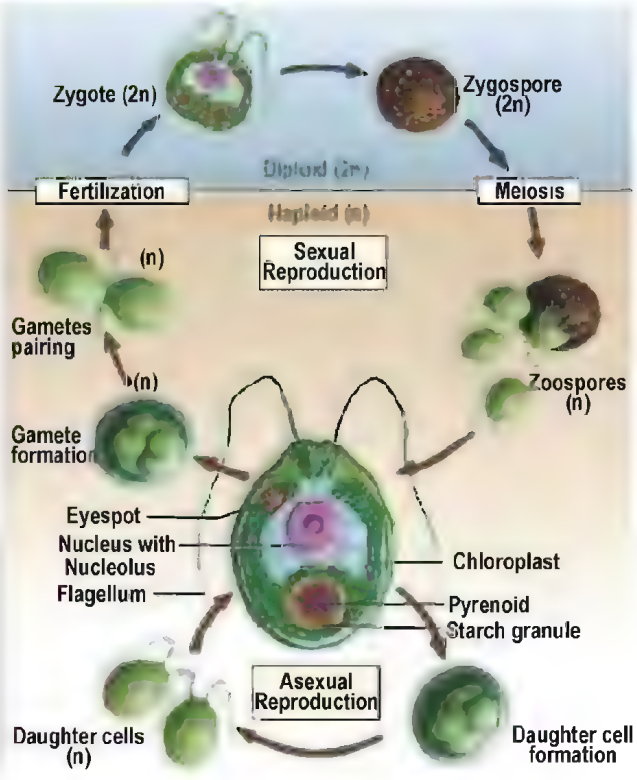


Figure 3.6 Reproduction in Chlamydomonas (for study)

Reproduction in Paramecium

Paramecium is from ciliated Protista spread out in lakes and pond water swhich contains water plants and dissolved organic substances.

1. Asexual reproduction in Paramecium

Paramecium reproduces asexually by **Transverse binary fission** which is explained as follows:

1. Division starts by normal division of **micronucleus**.
2. After division of micronucleus each nuclei moves to the opposite side of Paramecium, at the same time **macronucleus** extends and cytosome (mouth) appears.
3. Macronucleus divides by amitosis into two nucleus and move to the two sides of paramecium. New mouth and two new contractile vacuoles appear and also the body of paramecium stretches.
4. Paramecium divides into two new paramecia.

2. Sexual reproduction in Paramecium

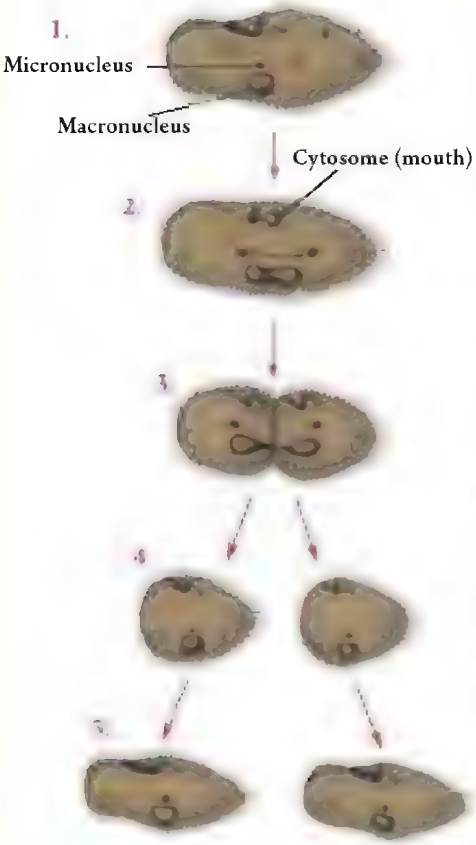
Paramecium reproduces sexually into two ways; **conjugation** and **autogamy**.

Paramecium reproduces asexually by binary fission

1) Conjugation

Conjugation in the Paramecium happens as follows.

1. Two individuals from the same type but from different strains meet and combine with eachother from the side which mouth located and they remain stuck to eachother for a short time, a cytoplasmic bridge formed between them which is temporary to pass or exchange of chromosomal substances.



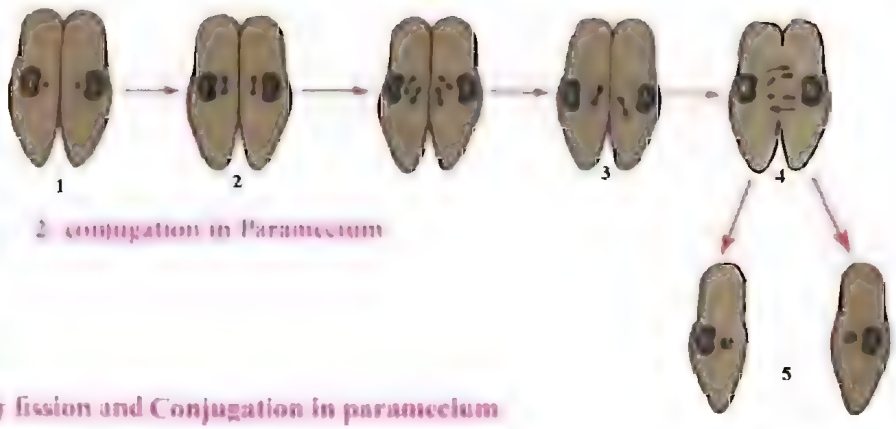
1- Binary fission in Paramecium

2. The micronucleus in both organisms undergos **meiosis** to form four nuclei, each of these nuclei contains half of the complete number of chromosomes (**n**).

3. Three of these nuclei dissolve and disappear; the fourth nucleus divides unequally by normal division in two nuclei. Each of these nuclei contains half of the complete number of chromosomes (**n**). They represent the primary male and female nucleus.

4. The male nucleus in the two conjugated organisms exchange and unites with female nucleus to form the **compact nucleus** which contains complete number of chromosomes (**2n**).

5. Each of paramecium reproduce asexually by binary fission and four new paramecia are formed.



2- conjugation in Paramecium

Figure 3.7 Binary fission and Conjugation in paramecium

B) Self-fertilization or Autogamy

Paramecium reproduces sexually into two ways; conjugation and autogamy.

Autogamy similar to the conjugation as above, except in-exchanged nucleus, while the two primary micro nuclei which contain half number of chromosomes (**n**) unite together to form an identical nucleus (**synkaryion**). It contains identical genetic factors (**Homozygous**) not contains different genetic factors (**Heterozygous**).

Reproduction in Euglena

Euglena is from protista which have flagella; it lives in lakes and current water which contain plants. Euglena is exist in free case and encysted in unsuitable conditions.

Euglena reproduces by **Elongated binary fusion** and this division happens in free-swimming stage and encysted stage as follows:

1. The nucleus divides by mitotic division to form additional flagellated protist.

2. The cytoplasm divides laterally and gradually until the two parts get separated completely to form two new organisms. Sexual reproduction in Euglena is not known yet.

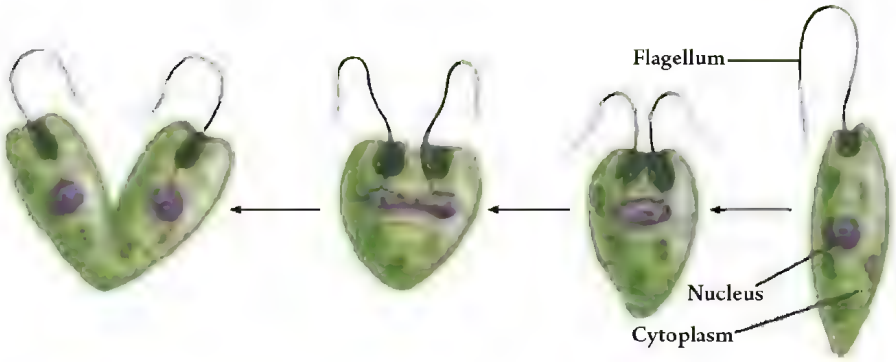


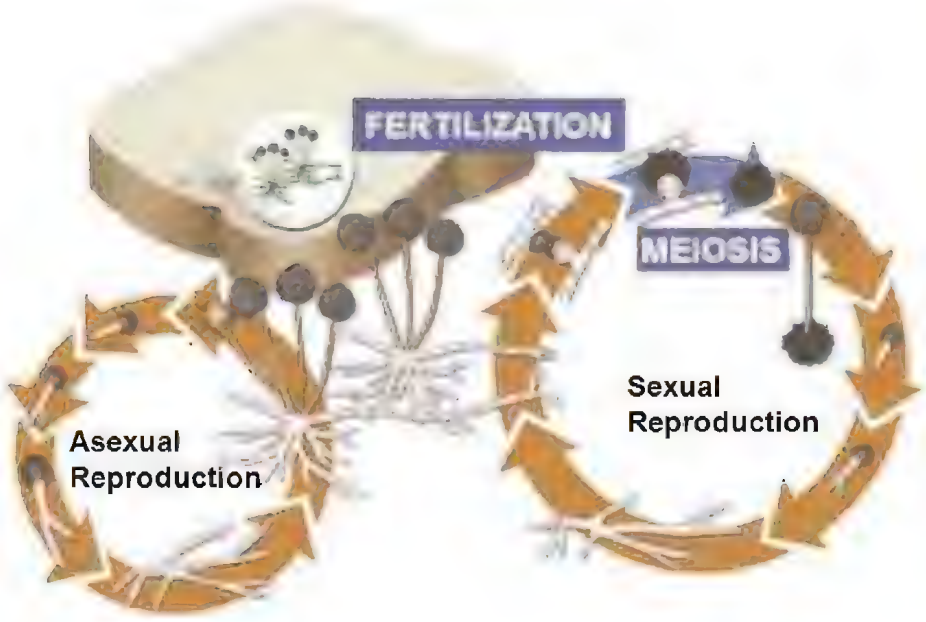
Figure 3.8 Transverse binary fission in Euglena

Reproduction in Fungi

The kingdom fungi contain more than hundred thousand type and they think there are similar number which has not been discoverd yet. Previously fungi were regarded as plants, which are similar to plants in reproduction property, growth and biochemistry. But later it was found that they are differ from plants in many ways. Fungi don`t have photosynthetic pigments so they are not autotrophic and also nutrition differ from plants.

Fungi don`t have photosynthetic pigments so they are not autotrophic and also they nutrition strategy different from plants strategy.

We will study reproduction in black bread mold as an example for reproduction in fungi. The black bread mold belong to **Zygomycota** which contain about 1050 types of fungi, the sexual and asexual reproduction in black bread mold happen as follows:



Hyphae are thread like filamentous structures that forms the body of fungus.

Figure 3.9 Reproduction in black bread mold (for study)

1. A contact and merging takes place between **hyphae** which contain different nucleus, positive and negative, followed by cytoplasmic integration.

2. **Gametangia** forms at the end of each hyphae, which contain positive and negative nucleus, in the end of each hyphae nucleic integration (two nuclei integration) takes place.

3. Gametangia merge and a pair of nuclei then join together to form **zygote.**

4. A thick wall forms around zygote and **meiosis** takes place.

5. The sporangiophore holds a sac called **sporangium** which splits to release the **spores** and contain half of the original number of chromosomes because it formed by meiosis. When it falls on nutrients (a process of bread for example) the asexual reproduction cycle starts and the process repeat.

Reproduction in plants

The plant kingdom contains eukaryotic, multicellular and autotrophic organisms. It is thought that plants descended from plants lived in fresh water represented by green algae which was about 500 million years ago. Scientists proved that this descends represent by both of them contain chlorophyll also different kinds of additional pigments and they store excess amount of carbohydrates as starch and cell wall in both contain cellulose.

In the plant kingdom alternation of generations appear and it is a clear phenomenon in reproduction of plants, it means the complete life cycle of plants would be in two stages, they are sporophyte and gametophyte as follows:

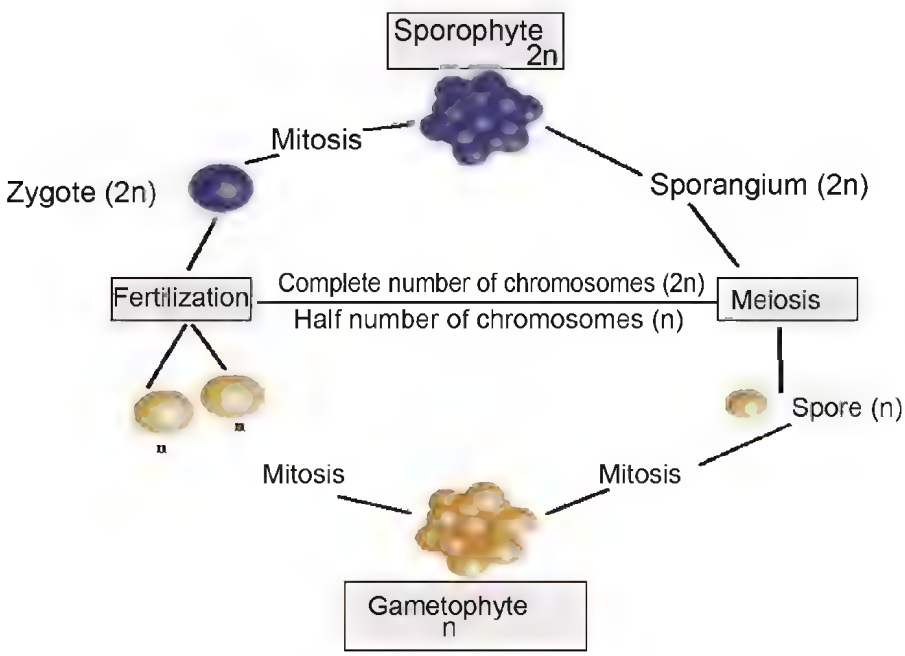


Figure 3.10 Alternation of generation in plants

1- Sporophyte

It is asexual stage which produces the spores; its cells have complete number of chromosomes (**2n**) and when this stage get mature some of its cells (mother cells) undergo meiosis for spore formation, because of this division there will be spores with half of the original number of chromosomes (**n**) and these spores indicate the starting of **gametophyte**.

2- Gametophyte

This is sexual stage and produce gametes, after the fertilization between male and female gametes sporophyte forms (alternation of generations). Notice that the size of the sporophyte bigger than size of the gametophyte in terrestrial plants which are exist now.

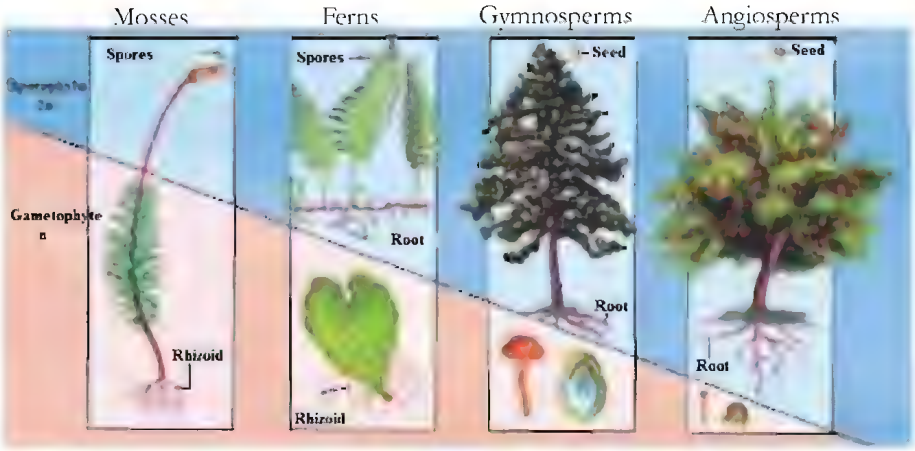


Figure 3.11 Reduction in size of gametophytes (for study)

We will study three examples for reproduction in plants, reproduction in mosses, in ferns and in flowering plants.

1-Reproduction in Polytrichum

Reproduction in Polytrichum happens in two stages, sporophyte and gametophyte. It is form of mosses which represents the biggest part of the non-vascular plants and includes more than **1500** and types and it happens as follows:

1. In the mature gametophyte the leafy stem carries **antheridia**; the male gametangia or **archegonia**; the female gametangia or both gametes.

2. The male gametes release from antheridia to the outside swim in water until reach the archegonia. Then fertilization takes place by merging male nucleus with female nucleus.

3. After the fertilization the zygote formed and sporophyte forms inside the archegonia.

Spores are asexually reproductive cells that can grow a complete organism without fertilization, spread easily and resist against unfavorable conditions.

4. The gametic tissue complete and it is holder of **sporangium;** which meiosis takes place inside it to produce **spores** which have half number of complete chromosomes (**n**).

5. The spores release after opening the cover and spores spreads out in the air because of wind which helps spreading of spores.

6. The spores grow into male or female gametophyte (**protonema**) this represent the first stage of gametophyte.

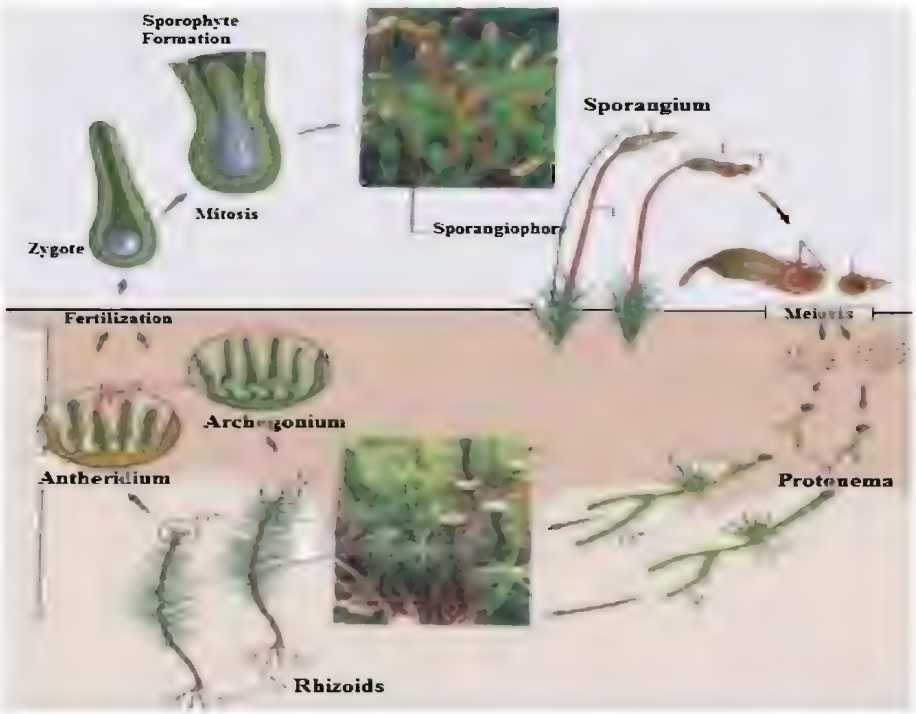


Figure 3.12 Reproduction in ferns (Polytrichium)(for study)

2-Reproduction in ferns

The reproduction in ferns happens in two stages, sporophyte and gametophyte. Ferns are type of seedless vascular plants, includes about 12,000 types. Reproduction happens as follows:

1. **Sporophyte:** is dominant stage in ferns. Sporangia are formed at lower surface of the leaves.

2. The spores are formed in sporangium and these spores have half of the complete number of chromosomes (**n**) because they produced by meiosis and spores release when the sporangium opens.

3. The spores grow into gametophyte which represented by **prothallus**. It is a heart shaped, green coloured structure and carries **archegonium** (female) and **antheridium** (male), it grows from the sharp side.

4. The fertilization takes place in moist media, the sperms swim in water to reach the egg within archegonium.

5. Zygote, the product of fertilization formed inside the archegonium and the first leaf appears above the prothallus and roots formed at below and the sporophyte appears.

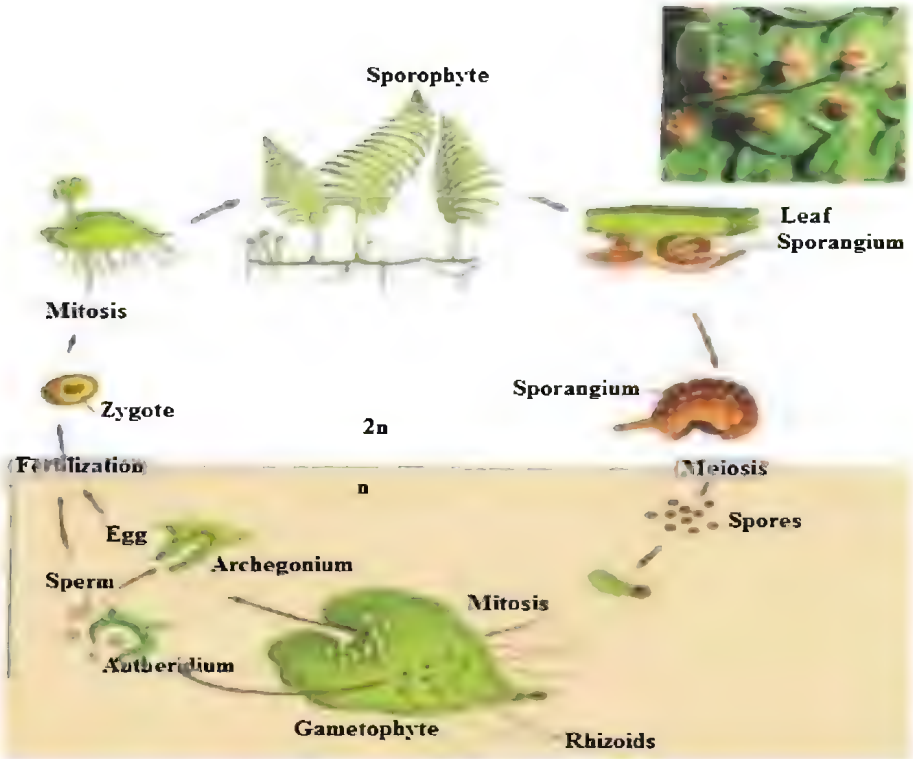


Figure 3.13 Reproduction in ferns (for study)

3-Reproduction in flowering plants

Flower represents the reproduction organ in flowering plants. Continuity of plants depends on reproduction in plants.

The flower is a specialized branch carries differentiated leaves which involved in sexual reproduction, producing fruits and seeds. Flower contains parts which directly related to the reproduction and other parts which are not directly related to reproduction. Flowers are formed from buds but differs from them by growing nature. For instance we see that flower organs are closed to each other and not isolated.

Flower consist of 4 parts as follows

1. Sepals

They make groups called **calyx**, which protect the bud before it gets to the full form. These leaves usually have green colour and stay attached to the lower part of flower.

2. Petals

These are called **corolla**. They have different shape, size and colour in different plants. Usually the number of petals equal to the number of sepals or its doubles. In **Iris** there are three sepals and three petals. However in the Rose there are many multiples of petals than sepals. Both sepals and petals have no direct role in the sexual reproduction.

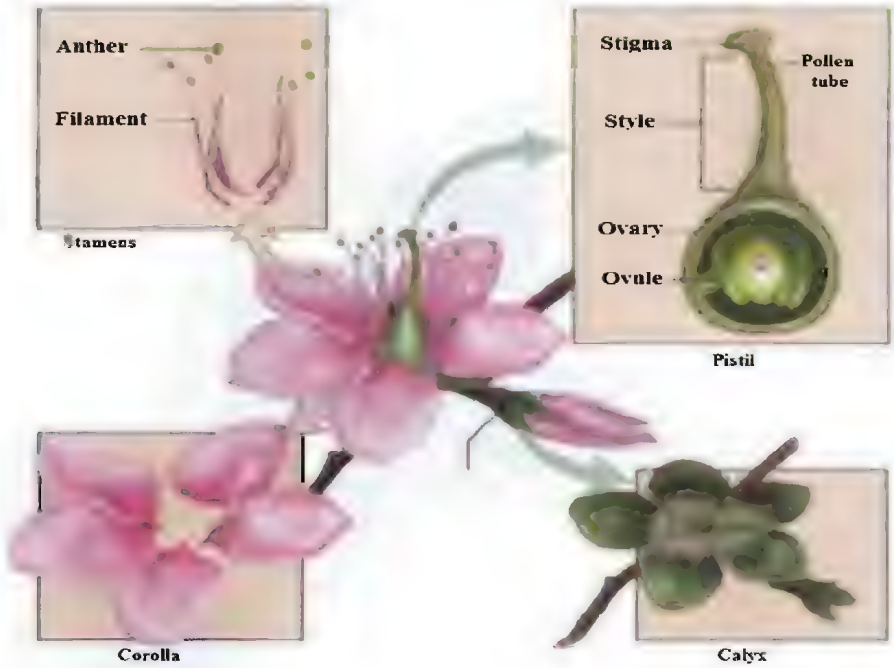


Figure 3.14 Structure of flower

3. Stamens

This is the male part in the flower. This is consisting of two parts, **anther** and **filament**. Anther has cylindrical bag shape or an elliptic shape which contains pollens and carried by holders called as filaments. Stamens are usually loose and they may bind together. The number of stamens may be different from one plant to another.

4. Pistil

This is the female part of flower which consists of following parts:

a) Ovary

This is the lower part of pistil and contains the "**ovules**" inside it, which are connected to the ovary wall by a short neck called "**funiculus**".

b) Style

It has a cylindrical shape and it is thin and hollow. It joints the ovary to the upper part called **stigma**.

c) Stigma

This is the final (top) part of pistil. This part is rather puffed up. This part will be somewhere covered by a sticky liquid to facilitate sticking the pollens to it. However different plants have no same structure of flower. Monocotyledon and dicotyledon plants have different forms of flower.

	Monocotyledons	Dicotyledons
1	Have one embryonic leaf	Have two embryonic leaves.
2	Have triple or multi triple flower parts	The flower parts are quantic or multiples.
3	Pollen with single pore	Pollen with three pores.
4	Parallel veined leaves	Net veined leaves.
5	Have adventitious (fibrous) root	Have tap root.
6	Generally herbal plants	Generally woody plants.

Table 3.1 Comparesion the differences between Monocotyledon and Dicotyledon plants.

Flower Terminology

	Property	Flower
1	Complete flower	All parts of flower exist (sepals, petals, stamens and pistil)
2	Incomplete flower	Some basic parts of flower are missing.
3	Perfect flower also called Hermaphrodite or Monocious	It has stamens and pistil.
4	Imperfect flower or Diecious	Have stamen alone or pistil alone but not both.
5	Sterile flower	Have no stamens or pistils
6	Inflorescence	Flowers as bundles
7	Composite flowers	They look as a single flower, but they consist of numerous small flowers

Table 3.2 Some scientific terms for different kinds of flowers

First: The formation of pollens and ovules

1. Anther and Pollen Production

Anther is made of two splits alongside with inner tissue which lies from the base of anther to its top. This tissue surrounds the vascular bundle. Each split of the anther is made of two compartments and each one called as **Pollen sac** or **Microsporangium**. The pollen sac contains **Pollen Grains**. When the Anther gets mature the connecting tissue between two compartments dissolves and two compartments become one compartment and open to the outside through vertical external split. Then the pollens will be ready to spread to the environment.

At the beginning the pollen sacs contain the microspore mother cells which have double number of chromosomes. The microspore mother cell divides by meiosis to form **microspores** with half number of chromosomes (**n**).

The nucleus of **microspore** divides in an ordinary way and each new nucleus will be covered by cytoplasm to form a **tube cell** and a **generative cell**. This represents the **immature male gametophyte**. The pollens spread from anther to outside approximately hundred numbers in each anther. The pollens are covered by a thick wall with horns or they are rough surfaced, taking different shapes according to type of plants. Pollens contain number of thin regions called germination pores.

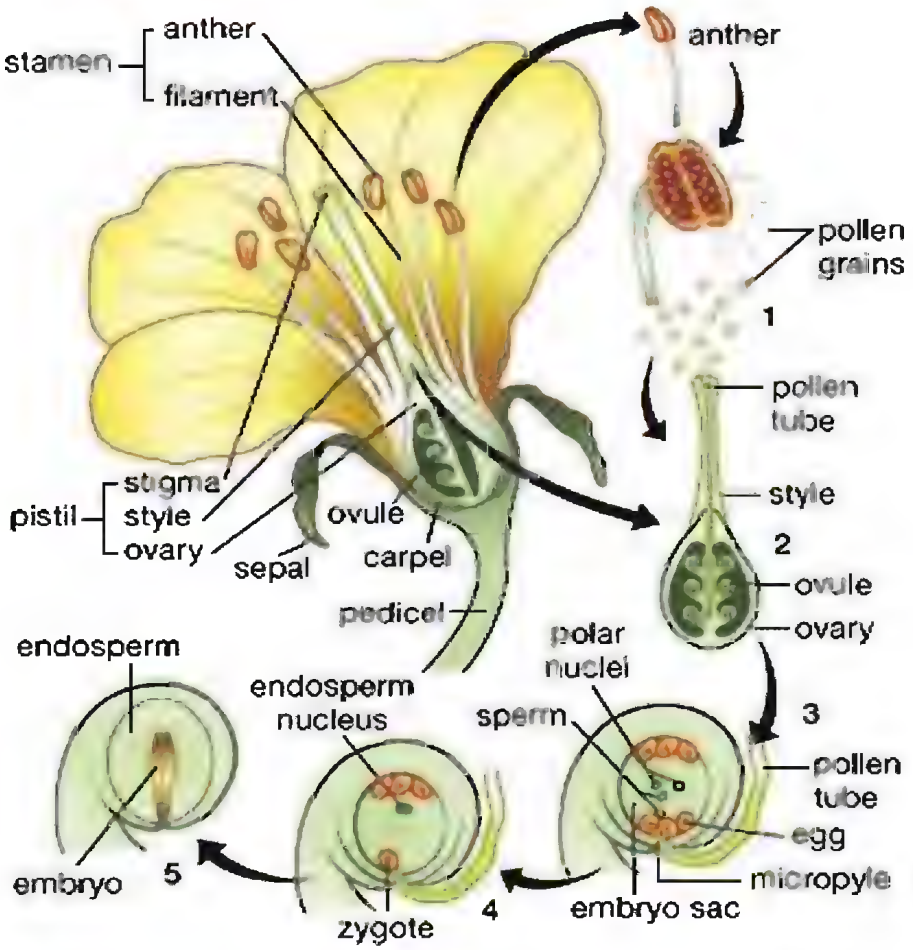


Figure 3.15 Life cycle of flowering plant (for study)

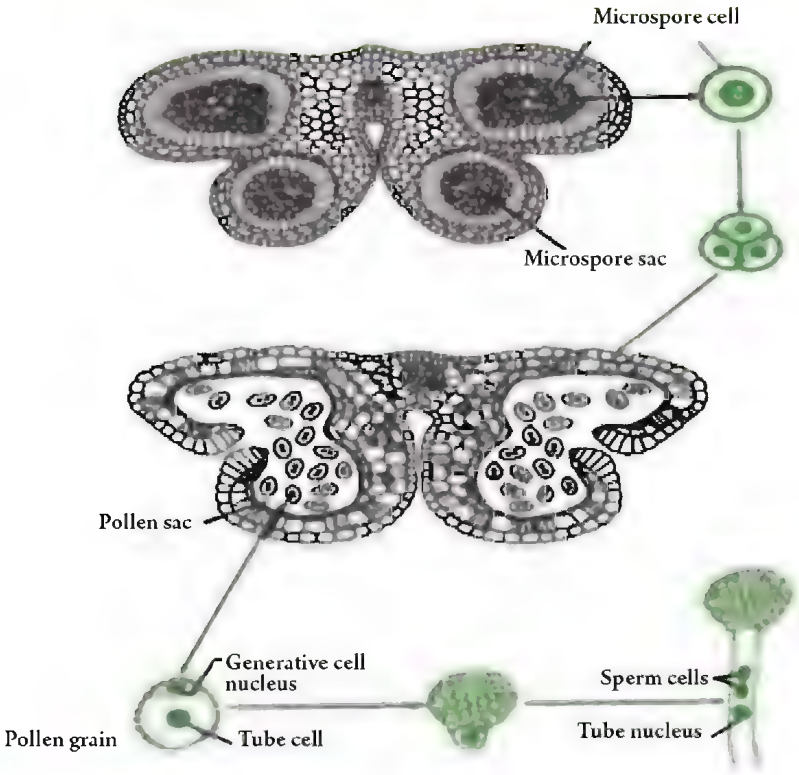


Figure 3.16 Pollen formation in flowering plants (for study)

2. Ovary and Egg Production

Pistil together with ovary made of leaves called as carpel leaves (one or many). The carpel leaves represents the **megasporophyll** where the eggs are attached to the ovary wall as a shell for **megasporangia**.

Egg start growing by having a small hump called **nucellus**, connected to the ovary wall through the **funiculus**. This is covered by one or more layers of ovary cover cells. These layers grow from the base of nucellus and cover the nucellus completely except the top part where it leaves a small hole called as **micropyle**.

A compound cell grows inside nucellus called **megaspore mother cell**. This cell undergoes meiosis in order to produce four **megaspores** with half number of chromosomes (**n**) on the same line.

Three megaspores disappear and the fourth one remains. This represents the female gametophyte which is immature and thin called **embryo sac**. This will grow in size as long as the cytoplasm grows together with the nucleus. This occupy the most of the ovary.

Three successive divisions take place in the nucleus of the embryo sac resulting in eight nuclei in the embryo sac. Three nuclei organize near the micropyle and three nuclei at the opposite side, two of them remain at the centre. Three nuclei at the micropyle side covered by membranes to form cells, the middle one represents the egg cell and the other nuclei at the two side forms two **synergid cells**. The nuclei of opposite side of micropyle within embryo sac also covered by membranes and it forms **antipodals**. Two central nuclei form two polar nuclei. The embryo sac represents the **mature female gametophyte**.

When female gametophyte gets mature, the mature egg formed in mature embryo sac and covered by membrane and nucellus. And funiculus looks curved to the bottom in a way so micropyle is near the funiculus and may takes other positions.

Pollination is one of the operations which lead to produce seeds and provide fertilization.

3. Pollination

Pollination can be defined as transporting of pollen from anther to the stigma of same plant or another. As a result of transporting **fertilization** takes place, so the pollination is one of the operations which lead to produce seeds and there are two types of pollination:

1- Self pollination

This happens by transporting of pollens from anther of a flower to the stigma of the same flower or to the stigma of different flower of same plant. This kind of pollination happens in many kinds of plants like wheat, barley, rice, cotton, beans, peas and orange trees.

2- Cross pollination

This kind of pollination happens by transition of pollen from anther of flower to the stigma of another flower fram another plant from the same kind and perhaps to the other kinds belongs to same species. The cross pollination happens in many plants and it is more important than self-pollination because the fruits are bigger in size.

That's why the farmers are advised to have bees house in the farms or nearby to guarantee cross pollination then to get a lot of and good quality products.

The bees are most important and helpful insects in pollination, so some economists estimate the profit of pollination by bees a huge amount of money (yearly average is more than 200 billion dollars) in the world.

There are also many other insects for example beetles,butterflies and others. Also the wind and water play a good role in transition of pollens then pollination and also human can do this job such as in date palm trees.

4. Development of Pollen Tube

The pollen grows after fallen on the stigma to form with a narrow diameter called as **pollen tube** usually each pollen produces one pollen tube.

The pollen tube grows and penetrates the stigma and the style until it reaches the ovary which contains eggs.

Although many pollen tubes are formed, but only one of them reach the egg.

The pollen tube grows up and generative cell undergoes normal division (once) to produce two sperm cells. So the pollen tube contains a **tube cell** and two **sperm cells**, the pollen tube represent the mature male gametophyte in this case and it is ready for fertilization.

The pollen tube represent the mature male gametophyte in this case and it is ready for fertilization.

5. Fertilization and Embryo Development

With arriving the pollen tube into the ovule, it penetrates the Micropyle and enters the nucellus then into the embryo sac and releases its contents in it. One of the sperm cells unites with egg to form **zygote** which has diploid (**2n**) number of chromosomes. The second sperm fuse with two polar nuclei to form **endosperm nucleus**, so this nucleus has triple (**3n**) chromosomal group. Union nucleus of one sperm cell with the nucleus of egg and union of the nucleus of second sperm cell with two polar nuclei is called **double fertilization** which is one distinguished characteristic of flowering plants. After fertilization is completed three antipodal cells, two synergid cells and tube cell disappear. Zygote starts normal divisions to form embryo. The endosperm cell undergoes many divisions to form endosperm tissue which contain nutrients to be used by embryo during growth stages.

Endosperm nucleus is triploid (3n) becuse it formed by union of two polar nuclei and sperm nucleus.

We can summarize the growing stages in dicotyledons as follows

1-Zygote Stage
In this stage double fertilization takes place and products are zygote and endosperm.

2-Pro-embryo Stage
In this stage the pro-embryo is multicellular by having non-functional parts.

3-Globular Stage
The embryo like a small ball in this stage.

4-Heart Stage
The embryo is in a heart shape and cotyledons start to appear.

5-Torpedo Stage
The embryo as torpedo and splits form and seen clearly.

6-Mature Embryo Stage
The embryo gets mature and starts to grow. It takes the shape of a real embryo formed from shaft, pre-root, pre-leaf and split stem.

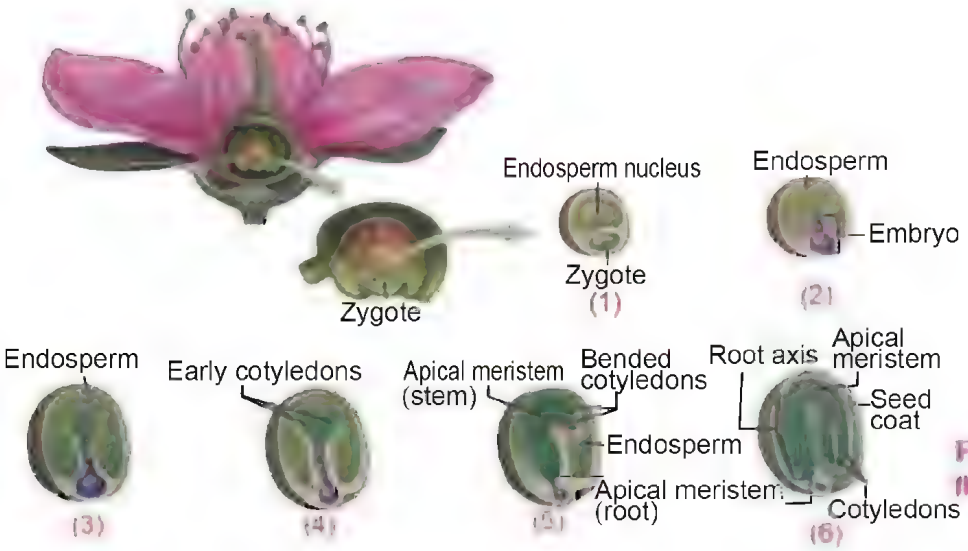


Figure 3.17 Embryo formation in flowering plants (for study)

6. Seed Formation

The formation of the seed starts after fertilization directly. So endosperm cell divide to form endosperm tissue and then grows and covering of egg transform into seed coat which define as **testa**.

The seed at the mature stage formed from embryo and a cover of seed as it is in most of the seeds in the dicotyledon plants like, **broad beans, green beans** and others. But there are types of plants as **wheat, corn** which the embryo doesn't use endosperm unless that seed has been planted and started to absorb water. The mature seeds usually formed from embryo, endosperm and also cover of the seed which is consist of one layer or more.

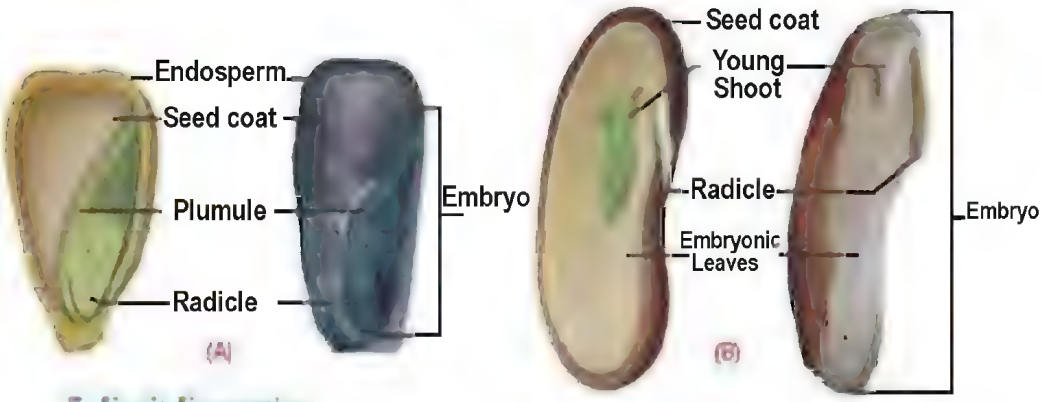


Figure 3.18 Seed structure in
A- Monocotyledon plants
B- Dicotyledon plants

7. Fruit Formation

Fertilization process regards as stimulator causing to expand the ovary

Formation of fruit starts by growth and expansion of ovary wall. This will be accompanied by the growth of the seed inside the ovary. Fertilization process regards as stimulator causing to expand the ovary. This expansion may include some other parts of flower such as the receptacle as in the case of **apples** and covers of flower as in **berries**. These kinds of fruits are called **false fruits**. A large quantity of food is needed to develop the ovary to the fruit. Foods such as **glucose** and **amino acids** are transferred speedily to the wall of ovary through tissues which link the parts of flower to the stem.

These food materials are converted and stored as feeding material like some complex sugars, proteins and oils. When the amount of sugar is high in fruits, this sugar makes it sweet. This in the case with fruits such as grape, dates, etc. Sugar may convert into starch at the maturity stage as in corn, grains and rice.

Oils can accumulate in the fruits with large quantities such as olives. In some other kinds of fruits water may be stored such as in watermelon, melon and tomatoes.

On the other hand some other kinds of fruits will have very low level of water content when they are mature such as walnuts, nuts and almonds. These kinds of changes to the fruit accompany changes to their color. For example chlorophyll disappears and replaced by **carotene** when some fruits get mature as in tomatoes. **Anthocyanin** can accumulate as in grapes and pears.

Pollen grains have two roles. First producing male reproductive cells which fertilize the eggs with double fertilization process and this produces the seed. The second role is stimulating special hormones which organize the maturity process of the ovary and converting it to fruits. Therefore this process can be replaced sometimes by sprinkling some hormones over the ovary of some flowers. These plant hormones affect the ovary to get mature and change it to fruit. This process called as artificial pathenocarpy and these fruits are called as **artificial parthenocarpic fruits**. However there are some kinds of fruits which naturally have no seed and these called as **natural parthenocarpic fruits**. **Pine apples** and some kinds of **grapes** are examples. It is believed that the ovary of this kind of flowers have high level of hormones.

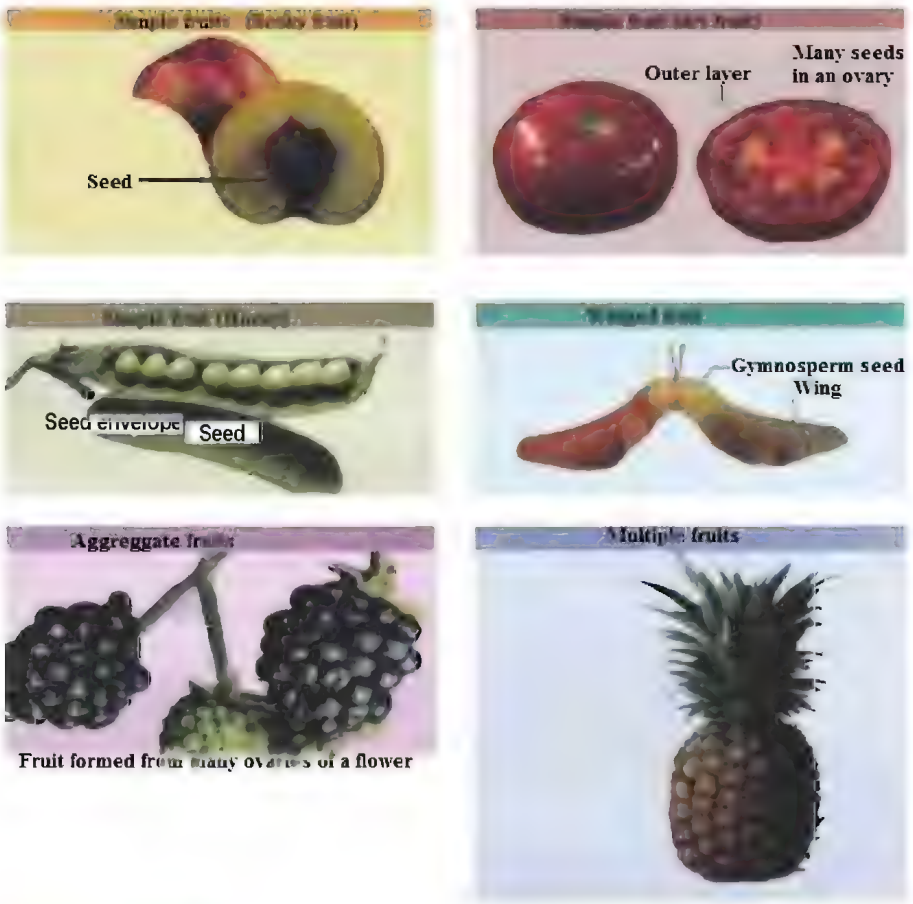


Figure 3.19 Some kinds of fruits (for study)

Structure of fruit

It is possible to define the fruit as a mature ovary with its contents and its coverings. Seeds are formed in fruit and consist of three layers. They are;

A) **Exocarp**; can be called as a **skin** or cover.
B) **Mesocarp**; can be called as a **flesh**.
C) **Endocarp**; can be called as a **pith**.

Notice that these layers differ in growth rate and thickness in different types of plants.

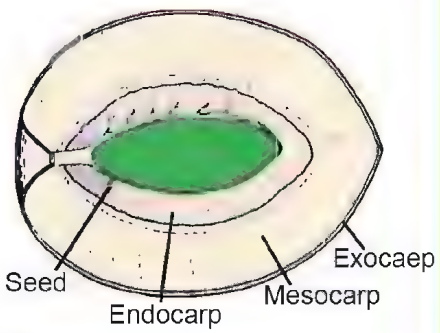


Figure 3.20 Fruit structure

Types of fruits

Fruits have various types we will summarize the common types of fruits as follows.

1. Simple Fruits

These fruits are product of one flower with one carpel or many carpels as in case of **broad beans, tomato, cucumber, orange** and **apricot.**

2. Aggregate Fruits

These fruits formed from many separated carpels. The fruits in this type come from one single flower as in **blackberry**.

3. Compound Fruits

They can be called as **multiple fruits** and formed from a group of flowers. Each flower forms a fruit and they remain connected to each other at the maturity as in the case of **pineapple**

Dispersal of fruits and seeds

Large number of fruits and seeds contain structures or different special parts help them to spread out easily in their environment or in similar environments by different factors which help to spread the fruit and the seed like wind, birds, and other animals, human and also the structure of seed and opening of fruits.

The wind carries the seeds and fruits away from the mother plants as it happens in the seeds of grass, weeds and desert plants. Since seeds are very light in weight or covered by hairs in umbrella shape as in the winged fruits.

The animals also help to spread the seeds and the fruit so that some seeds contain prickles and it sticks the skin of the animals so it transfers it to far distances from its position.

Many water plants depends on water waves to transfer its seeds and fruits in order to keep the species, usually the seeds and fruits of these plants are light or their cover contain vacuums which help seed to float on the surface of the water as in coconut.

Figure 3.21 Dispersal of fruits and seed by animals

Vegetative propagation

It is a common type of asexual reproduction in many plants and ferns. The plants have vegetative propagation in many ways, by stolons; they are stems extend on the surface of the ground. Rhizomes or Tubers, Corms and Bulbs. All these parts are vegetative parts of plant and they are not related to the sexual reproduction but act in vegetative propagation. There are three general types of vegetative propagation.

A) Natural vegetative propagation

This happens in many ways

1. Propagation by Stolons

One of the vegetative propagation types as in **strawberry**. A horizontal stem (stolon) which can be a meter in length extends above the surface of the ground. The stolons form new vertical plants on the knot positions on the stolons. New roots grow in ground, stems and leaves grow to up. The new plant separates from the mother plant naturally and when stolons die it can be taken and planted in other places.

Figure 3.22 Types of vegetative propagation in plants

2. Propagation by Rhizomes

This is a vegetative propagation way which most of the weeds and ferns reproduce. It happens by formation of terrestrial stems, which extends under the soil surface and called as **rhizomes**. Roots grow from horizontal stem and green parts grow from the buds above the ground. Terrestrial stems extend by the growth of their apical buds and covers new areas in a great speed. **Garden grass** and **Iris** are examples for this type of reproduction.

3. Propagation by Tubers

Tubers can be defined as food storing terrestrial stems. Tubers contain number of lowness called eyes. Each eye contains a bud or many buds called **axillary buds**. Usually one plant has a group of tubers which are capable to form new branches from its bud as in **potato**.

4. Propagation by Bulbs and Corms

This kind of vegetative propagation happens in many herbaceous plants by formation bulbs. A bulb is a single, globular, big bud. It has a disk stem at the base end and some leaves grow from its upper surface and roots grow from lower surface. Buds are emerged from axils of leaves and these buds similar to the mother bulb. It may separate or remain connected to the mother bulb. **Onion, garlic, narcissus** and **lily** are examples for this type of propagation.

Corms also a method of vegetative propagation similar to the bulbs in morphology but differs in the big part of corms is a stem tissue; the leaves are thinner and smaller than the leaves of bulbs. Corms also reproduce by forming buds from the axil of leaves on stem and separate to form new corms as in **gladiolus**, **earth apple** and **turmeric**.

B) Artificial Vegetative Propagation

Many plants lose their ability to form active seeds as in banana, grape, and some kinds of orange. And also some plants take long time to reproduce by seeds like date palm, and also there is difficulty to guarantee to limit the species and genus of tree, therefore the farmers resort to propagate the plants vegetatively. There are some plants cannot reproduce vegetatively and they need stimulation to propagate by using some plant hormones like; indole acetic acid, indole butyric acid and naphthalene acidic acid.

The ways of artificial vegetative propagation as follows

1. By offsets

Offsets are big buds frequently formed at the stem base in the region of its connection with the soil. Adventitious roots, which extend in soil, are formed from them. And when their growth completes, they are separated from the mother tree. Then they are translocated and grow in another place in the form of an independent plant. Among plants, which are propagated by this way, are **date palm** and **banana**.

2. By layering

Some plants can form adventitious roots if they touch the earth and are covered with soil. Man has utilized this characteristic in propagating some plants in that a twig is bended while it is still connected with the mother plant and part of it is covered with some quantities of soil. This process is known as **layering**.

If the bending of the branch is difficult because of its hardness for example, it can be **aerial layering** by enclosing it with a soil-containing pot and leaving it for a period of time (about 6 weeks) in that part of the branch, buried in the pot, forms adventitious roots. Then, the branch, which has become containing roots, can be separated from the mother plant and grown in another place. Among plants, which can be propagated by layering, are **grape**, **lemon** and **orange** and others.

3. Propagation by Grafts

The process of grafting is the attachment part of a plant to the part of another plant. This method is used to reproduce plants with desired properties. It is noticed in the experiment if a part of plant taken which has buds as orange and it replaced on another plant similar to characteristics as lemon, the bud of orange will grows forms flowers and fruits on **lemon tree**.
The part which contains the buds is called **scion** while the other part is called as **stock**.

There are two main types of grafting

a. Budding Grafting

A bud is taken from a plant with desired properties placed in a split of T shape within the stock. Their two sides are lifted and the bud is inserted in it and covered again with two sides then the bud tied up in its place.

b. Cleft Grafting

Cleft grafting is carried out by cutting the stem of the stock tree horizontally near the soil surface. Then a vertical split is made in it. Afterward, a branch containing a number of buds is taken from the scion and its end is trimmed in such a way that it fits the split and it is put cautiously in such a manner that cambium tissue fit one another in the scion and stock. Then this place is tied up and covered with the wax.

It is important to know that grafting always not succeeds, only if there are alike properties between scion and stock. Means they must be from the same class of plants, so orange cannot grafted on peach but can be grafted on lemon and also peach can be grafted on plum.

Propagation by Grafts is used to reproduce plants with desired properties.

Figure 3.23 Vegetative propagation in plants

Reproduction by cuttings : using plant cuttings to reproduce plants from existing plants (for study)

The importance of Vegetative propagation in plants

The vegetative propagation is used in plants for many purposes.

1. To propagate the plants which do not produce seeds
2. To propagate hybrid plants without change since their seeds do not give all of the plants which are similar to the parents.
3. To propagate plants which the seeds are germinated at low rates.
4. To increase the propagation speed and speed-up the fruiting.
5. To adapt the plants to new conditions. For example, roots of the pear trees do not grow well in a sandy soil but they can be grown in such a soil successfuly by way of grafting it on stocks of peach trees of which the roots blossom in this soil.
6. Preventing the affection by some parasites, which attack roots of specific kinds and do not attack other kinds. For example, roots of the European grape are subject to be affected by a type of parasites, which do not hit roots of the American grape. If stocks of the American grape are grafted by those of the European grape, the latter grow without being exposed to these parasites.

Plant tissue Culture

The plantation of plant tissues is regarded as one of the applications of vital techniques which help in reproduction of plants and this represents the artificial vegetative propagation. Simply it means; the development of plant tissue and cells outside the plant body, in environment or in proper feeding media. The result is formation or development of plant buds which transformed during proper time to form a mature plant.

The advantage of this tissue plantation in plants, to get a plant with desired properties. The salt resistance and the changes in temperature and it also used to overcome some plantation problems like long life, as in date palm tree.

The tissue plantation become common in the world and in Iraq, some studies at research centres achieved a success in this field.

The tissue plantation for date tree can be summarized as follows

1. One of the offsets is separated from the mother plant; mostly a desired offset is selected because it has an active growth.
2. The apical growing part extracted and this requires sterilized media to prevent contamination of extracted tissue.
3. The apical growing part partitioned into small pieces, because it contains active cells.
4. The tissue planted in media which contains nutrients, reliable humidity and temperature. After transplanting it to a normal environment.

Reproduction in Animals

The members of the animal kingdom show a big difference in reproduction ways and mostly reproduce sexually but some animals which reproduce sexually and asexually, the basic structure of the reproductive system in animals is similar although there are some differences in reproduction habits and fertilization ways which made many changes especially in vertebrate.

We will study some examples about reproduction and reproductive systems in individuals of animal kingdom

Reproduction in hydra

Hydra belongs to class Hydrozoa they mostly are sea-living animals but there are some that lives in fresh water. It lives individually or in colonies, the ideal life cycle of hydra in two stages, asexually stage **Polyp** and sexually stage **Medusa**. Notice that hydra of fresh water doesn't have sexual stage medusa, some kinds of hydra have sexual stage only without asexual stage. Hydra reproduces asexually and sexually.

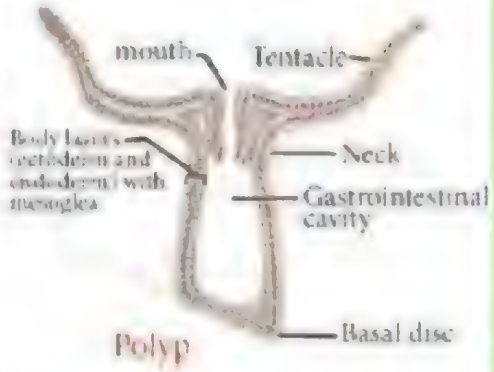


Figure 3.24 Sexually (Medusa) and asexually (Polyp) form of hydra

1- Asexual Reproduction

Hydra reproduces asexually by **budding**, and this kind of reproduction happens when the food is available, so mostly at the beginning of the last third of the body it forms a little bulge is called bud which contains vacuole that represents the main vacuole for the mother animal.

The bud grows and extends, and when it reaches the suitable size at the far end the little bulges will appear and grow, then the mouth forms, during several days the bud grows and appears as a complete formatted small animal which is connected to the mother, and after a short period it pinches of at the base of the bud and in the connected area with mother body. And then the bud separates from the mother and it closes its base and also closes the hole which was left in the mother body, then the independent life starts. The one animal may forms many buds which grow into new individuals.

Hydra reproduces asexually in another method which is **Fragmentation and Regeneration**, it has been found when hydra cut into many pieces most of them renews into a small size complete hydra.

2- Sexual Reproduction

- Hydra is present in nature either **Monoecious** or **Hermaphrodite** so the animal has **ovaries** and **testes** in the same individual. There are some kinds of hydra separated sex (**Dioecious**) so the testes are in one animal and the ovaries in another animal.

- Hydra gets stimulated to form ovaries and testes in certain circumstances as changes in the temperature and raising the concentration of carbon dioxide in the water especially in the season of autumn.

Figure 3.25 Budding in hydra

- **Gonads** form in shape of bulges which is covered by the outer layer for the body wall, the testes usually take a cone shape in the upper half of hydra's body; the ovaries are sphere structures takes position in the lower half of the body near the lower disc.

- Testes are formed from **interstitial cells** which are available in the body wall, and these cells are not differentiated and it may differentiate to form any kind of cells when is needed. The interstitial cells form spermatogonia which passes through a sequenced formation stage to produce sperms that collects in an expanded structure which opens out to release the sperms into the water and it finds its way to the egg.

- The ovary also forms in the same way as testes and differentiates at several interstitial cells to form oogonia. The size of one of the oogonia increases and usually the central oogonia increase, which supplied by food from the adjacent dissolved cells. The oogonia will have formation stages to produce big sized mature ovum. When the ovum formation is complete, the surrounding skin layer splits and the ovum remains stuck by the base of the ovary until it meets the sperms, then fertilization takes place and the zygote is formed.

The zygote passes by formation stages which are stuck by the mother body and then separates from it after it has been covered by protective layer to resist unsuitable environmental circumstances, in the season of spring young hydra come out.

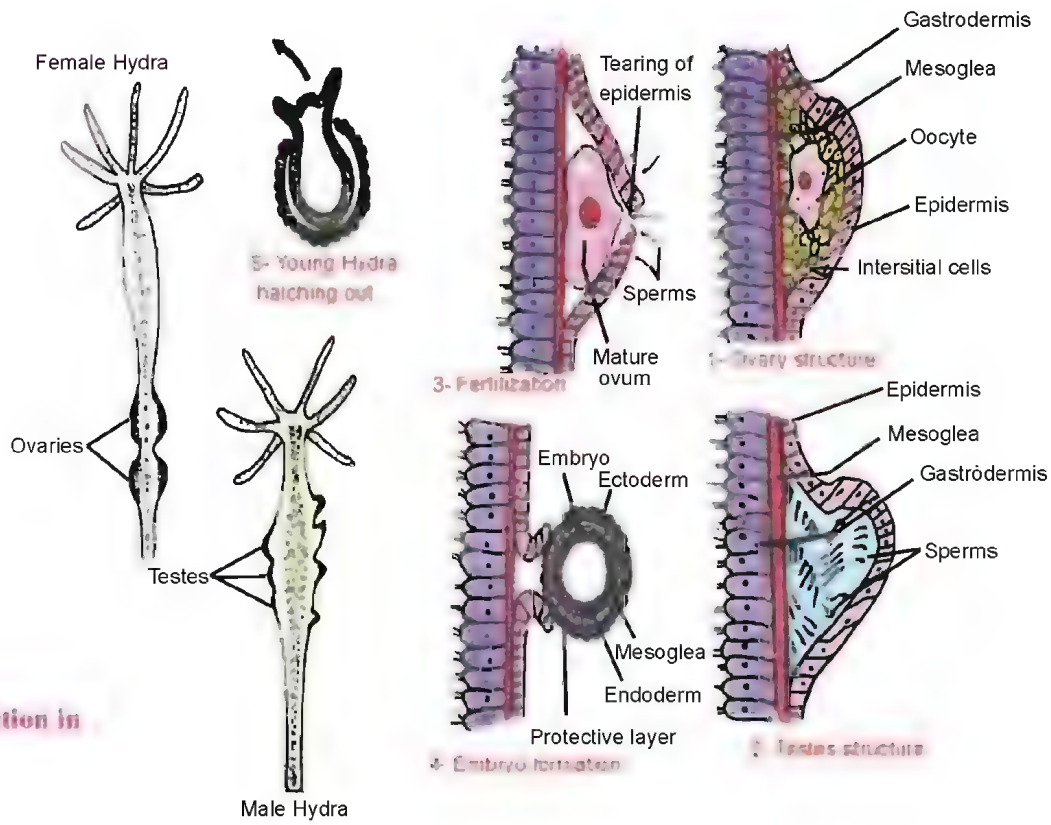


Figure 3.26 Sexual reproduction in hydra

Reproduction in Planarian

Planaria belongs to tape worm (flatworm) class which includes a big variety of worms its length varies between 1mm to several meters as in tape-worm, and its flat body is thin and horizontal as the leaf of the tree or looks like a tape.

Sexual and Asexual Reproduction in Planaria

1-Asexual Reproduction in Planaria

Planaria reproduces asexually by **Fragmentation and Regeneration**, when the worm is cut into many pieces; these pieces grow and renew to form new complete worms.

The laboratory experiments have proved that fragmentation represents a procedure which brings attention in laboratory studies for example if a piece from the middle of planaria worm is removed it may form a new head and a new tail by fragmentation.

This piece keeps its original poles, so the head grows at the front side and the tail grows at the back side. Planaria of fresh water reproduces asexually by **binary fission** so the animal pinches off behind the throat and it pinches off more gradually then the animal divides into two individuals, each one of them complete the missing parts.

Figure 3.27 Asexual reproduction in Planaria (fragmentation and regeneration) (for study)

Binary fission in Planaria is a quick reproduction method, the animal heads towards this method when the population decreases.

2-Sexual Reproduction in Planaria

Planaria is **hermaphroditic**; the same animal has got male and female reproductive organs. The male reproductive organs consist of many sphere shaped testes which are connected to the **vas deferens**. The vas deferens is connected to **penis** on both sides; the penis enters into the **genital cloaca**.

The **seminal vesicle** is situated at the base of the penis. The sperms formed in the testes and it passes by the vas deferens to seminal vesicle which remains there until it is needed.

Female reproductive organs consist of two **ovaries** and two long **oviducts** where many glands connected to them, **uterus** and **vagina** where they are open to genital cloaca. The eggs form inside the ovary and it passes to the oviduct then into the uterus, the fertilization takes place then the **cocoon** is formed.

During the intercourse,the sperms transfer from an animal to another two intercourse animals or two conjugated animals the reproductive organs are designed to prevent self-fertilization.

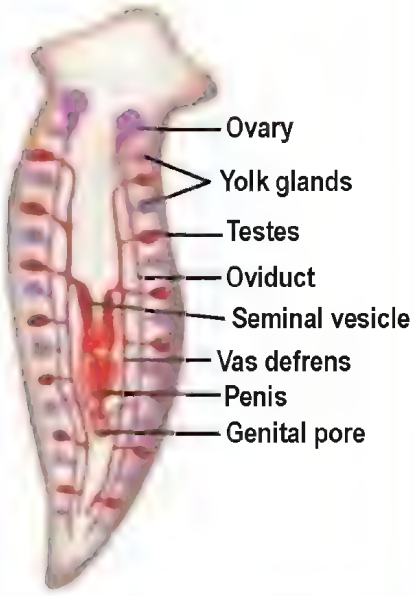


Figure 3.28 Reproductive organs of Planaria

Reproduction in Earthworm

Earthworm belongs to class Segmented worms, this class is very wide and it includes around **9000** types and the most common one is the earthworm, freshwater worms with a few pili, but the sea worms represents most of the individuals in this class (two third of class individuals).

Earthworms reproduce sexually and it is hermaphroditic, so the male and female reproductive organs are in the same animal.

Male reproductive system consists of the following:

a. A Pair of small testes which are positioned in the each body segments **10** and **11**.
b. A Pair of **sperm funnels** each one is represented by funnel structure situated near each testes.
c. A Pair of **vas deferens** extends into segment **15** and each one of them is opened into a separate hole on the abdominal surface for that body segment.
d. The testes, sperm funnels and the vas deference of each side gets covered by three **seminal vesicles**, the total is three pairs of seminal vesicles for each side.

The immature sperms transfers from the testes to get mature inside the seminal vesicles, then passes into the sperm funnels then into the vas deference finally into the male genital openings in the body segment number **15** and comes out during the intercourse.

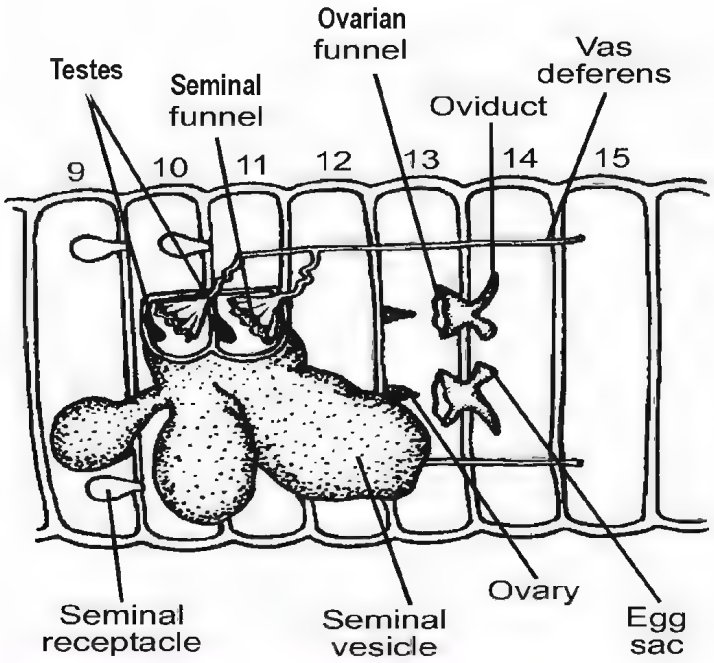


Figure 3.29 Reproductive organs in earthworm (for study)

Female reproductive system consists of the following

a. A pair of small **ovaries** which are situated in the body segment number **13**.
b. A pair of fimbrea funnels which are situated near the ovaries within the same body segment and it extends to the next segment.

c. A pair of **oviducts** which extend to the segment number **14** and they are open separately through the female genital opening on the abdominal surface for the body segment number **14**

d. Two pairs of **spermatheca** (seminal receptacle) in the segment number **9** and **10**, the first pair opens into the furrow between segment **9** and **10** and the second pair opens into the furrow between segment **10** and **11**.

Intercourse in Earthworm

The intercourse in earthworm usually happens during the night and especially in moist hot climate in the seasons, spring and summer. During the intercourse each one of the animals extends the front side from the hole which they are located in, so the abdominal surfaces of the two worms are faced to each other in opposite directions, so the **saddle area** (clitellum) for each worm will be opposite the spermatheca openings of the other worm.

The two worms attach to each other by mucus which is secreted by the saddle and the body of each worm will be covered by mucus layer from the segment **8** to the point before the saddle.

The two worms exchange the sperms which are released from vas deferens opening that is located on the abdominal surface for the body segment number **15** from each worm, the sperms of each worm goes under the mucus layer towards the saddle to enter to the opening of the spermatheca for other worm (the fertilization is cross, that means each worm gives its sperms to the other worm during the copulation).

The saddle in each worm starts excreting mucus substance to form mucus tube on the saddle called **cocoon**.

As a result of moving the cocoon slips and while passing the body segment number **14**, which the oviducts openings are, so it release off the eggs inside cocoon and when it arrives to the seminal receptacle openings it releases sperms in it, in this case the cocoon contains the eggs and sperms.

The cocoon slips off on worm's body to be free completely, after that the fertilization takes place. The cocoons gives off in moist soil, inside the cocoon formation of new individuals start without passing caterpillar stage, after two – three weeks the cocoons split and new worms similar to adults comes out.

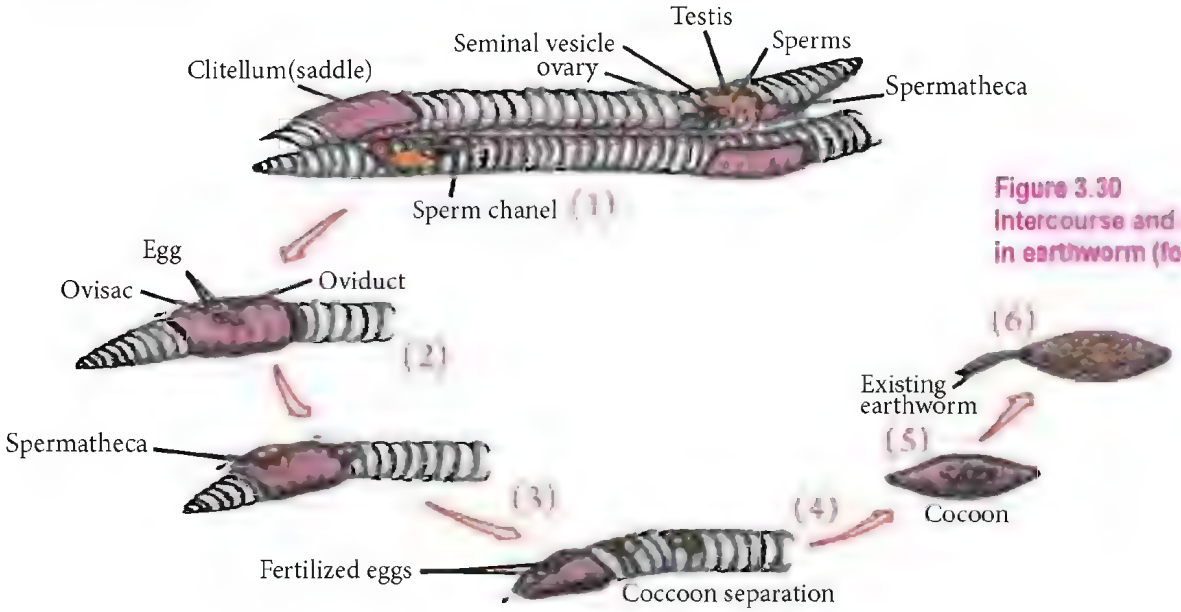


Figure 3.30
Intercourse and coccon formation in earthworm (for study)

Reproduction in Insects

Insects show big differences in reproductive systems and reproduction methods; this difference comes of a huge variety of insects. It's the most various animal group, and includes nearly a million types.

Insects usually are **dioecious**, the two sexes are separate into male and female, most female insects are bigger size than males, there are other differences between male and female which are colour, having wings or not, shape of antenna and the legs.

Reproductive organs in Insects

The reproductive organs in male and female are not differentiated until the growth stage after embryo formation is completed, different kinds of insects have different reproductive systems, in general reproductive organs in insects divides into two parts:

1. The inner reproductive organs, consist of **gonads** and a group of exported canals and some supplements like **glands**, **spermatheca** and some other.
2. The external reproductive organs, this represented by **ovipositor** in female and **copulation apparatus** in male.

1-Male reproductive system in Insects

Male reproductive system consists of the parts and the structure as follows:

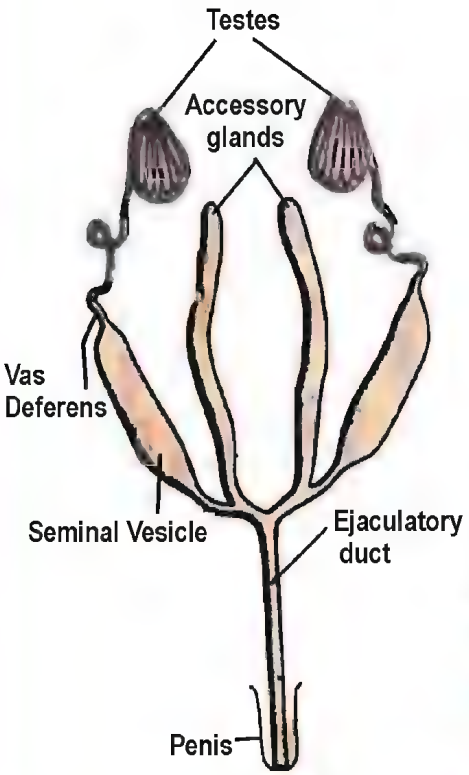


Figure 3.31 (a) Male reproductive system in insect

1. Two testes which are located above the digestive tube or on its side, the testes in insects consist of group of small tubes called **seminiferous tubules.**
2. Seminiferous tubules opens into small canal on the same side called **vas deferens**, the front part of vas deferens is connected to the testes, and the back part is connected to the seminal vesicle which represents wide area of vas deferens.
3. Two vas deferens unites to form **ejaculatory duct** which extends into the **penis**, and this opens in the end of it to the reproductive opening which releases the sperms from it.
4. Two accessory glands which located in the beginning of ejaculatory duct and they secrete mucus liquid which surrounds the sperms and it forms sac structure around it called **sperm sac**.

2-Female reproductive system in Insects

Female reproductive system consists of the following parts and structures:

1. A pair of **ovaries**, each one of them consists of a number of ovum tubes called **ovarioles** and these tubes don't contain a vacuole, ovarioles contain oogonia and oocytes. And also contain **nurse cells** for their (oocytes) nutrition.
2. Two oviducts on the sides and the back part of each ovary are connected to an oviduct on each side. Two oviducts on the side unite to form the main oviduct into it.

3. Seminal receptacle; this is a sac structure belongs to female reproductive system in most insects and some insects have two or three seminal receptacles usually a gland connects to the seminal receptacle called a **gland of seminal receptacle** which secretes a liquid to keep the sperms while it stays there. Seminal receptacle connects to the back wall of **vagina** and it receives the sperms during mating after that it releases them to fertilize the eggs.

Accessory glands, these are represented by a pair of glands which are connected to the end of it to be open in the vagina. Vagina; is the back part of the reproductive system where the main oviduct opens the function of the accessory glands varies in insects, in some insects the accessory glands are responsible for forming the ovisac as in cockroaches it is also used as defence as in bee and in ants the accessory glands are used to mark its path.

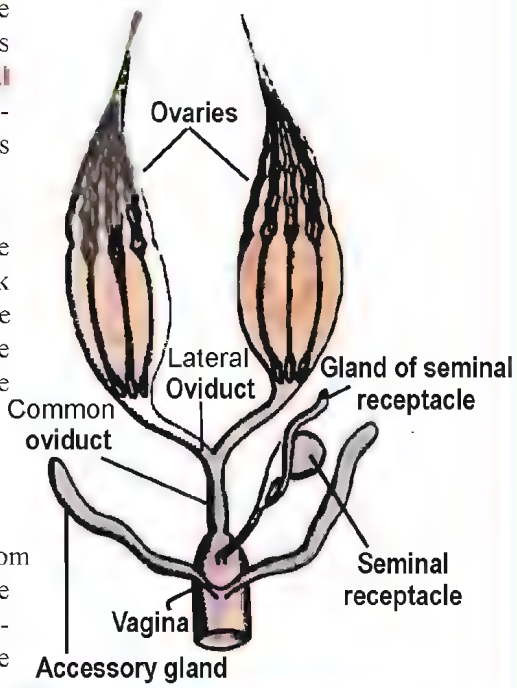


Figure 3.32 Female reproductive system of insect

Fertilization and reproduction

Fertilization takes place when two adult insects male and female from the same type meet and then mating will take place. During mating the male reproductive opening flops on female reproductive opening, so the male ejaculates the sperms into the vagina and female releases its mature eggs in the vagina too, the sperms fertilizes the eggs.

Female insects usually lays its zygote in places which have suitable environment for its growth, it lays the eggs in holes which it digs them by ovipositor or sticks them on plants leaves, or lays them in holes.
In this case the insects called **oviparous**, and the reproduction defines as **ovipary**.

There are some insects lays larva instead of eggs, these insect called viviparous and can be **ovoviviparous**, this kind of insects keep the zygote inside its body certainly in the oviducts, the embryo will grow and develope and the egg. hatches then the small insects come out.

Reproduction in Frog

Frog belongs to Amphibian class within vertebrate phylum; it represents the example which explains the strategy of body forming in quantic feet. Frog reproduces sexually; we summarize the contents of male and female reproductive system in frog and also reproduction in frog.

1. Male reproductive system in Frog.

Male reproductive system in frog consist the following;

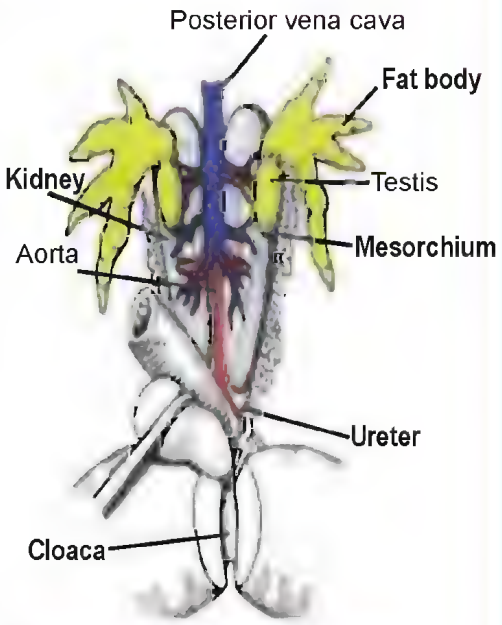


Figure 3.33 Male reproductive system in frog (for study)

A pair of testes which are attached to the kidneys, the testis stretched egg shape structure, and its light yellow, it connects to the inner wall for the body by **mesorchium**. There are many finger shape projections near the front end of the testes, these called **fat body**. It represents food store, the animal use it for the growth of the testes during the winter season. Testes contain wiggled seminiferous tubules with internal wall which is responsible for spermatogenesis.

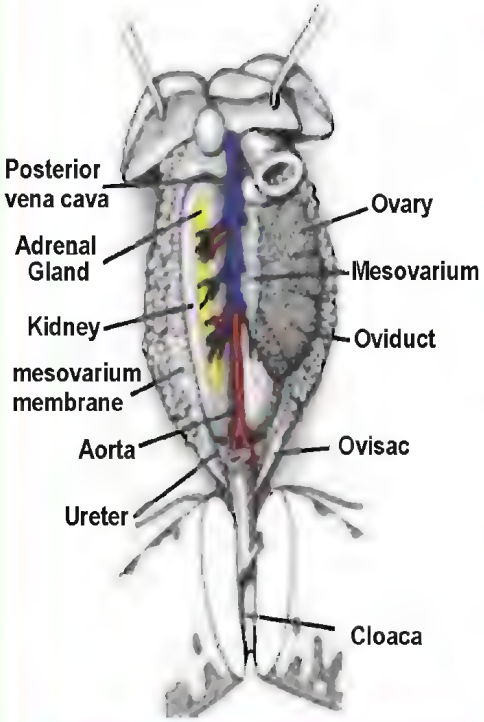


Figure 3.34 Female reproductive system in frog (for study)

Vasa efferentia, numbers of them are 10-12 which connects to **seminiferous tubules**, and it connects to kidneys tubules.

Two vas deferens these are joint canals with kidneys canals therefore it they called **urogenital ducts**, they transfer the urine and the sperms and it opens into the **cloaca**, in some frogs the back part of vas deferens can expand to form **seminal vesicle** the sperms will be stored in it. Frogs don't have external male mating organs.

2. Female Reproductive system in Frog

Female Reproductive system in frog consisted the following structures.

Two ovaries which are located near the kidneys, they connect to the inner body wall by **mesovarium**, the ovary in frog is irregular sac structure it appears as a sac with multi-clove. And its colour is black to grey, there are adipose bodies in the front end of the ovary, as in male, the two ovaries will be expanded a lot during the reproduction season.
The eggs formed from germ cells which is in the lining of the ovary through **oogenesis**.

Two oviducts, the oviduct in frog is wiggled, long, white tube and it doesn't connect directly to the ovary, the front end of each oviduct is a funnel structure with fimbrea opening, the function of fimbrea is represented by moving the eggs to the back. There are glands in the inner layer of oviducts which secrete albumin layer around the eggs while passing in the canal, the back end for each oviduct will expand to form **ovisac** which the eggs are collected before it gets released. Oviducts are open by two seperate openings in the wall of cloaca.

Mating and Fertilization in Frog

Sexually mature frogs gathered with each other in reproduction season which is usually in spring season, they are available in the lakes with shallow water, the male frog hugs the female by its front parts, the first finger in male is expanded to form **nuptial pad** which helps to hold the female, the frogs stay like that for period of time, so the male presses on female's body, then female starts to release its eggs in the water, and at the same time male starts to ejaculate sperms on the eggs, so fertilization takes place, and usually the one egg will be surrounded by a big number of sperms, but only one sperm succeeds in fertilization, and then the zygote will be formed which represents the beginning of forming a new animal.

Fertilization takes place outside the female body, this is called **external fertilization**. After that the zygote will pass by cleavage stage and **tadpole** forms which it has tail, with growth progress and having morphology changes, the tadpole will lose its tail and the gills which will have lungs instead to achieve respiration in adult frogs.

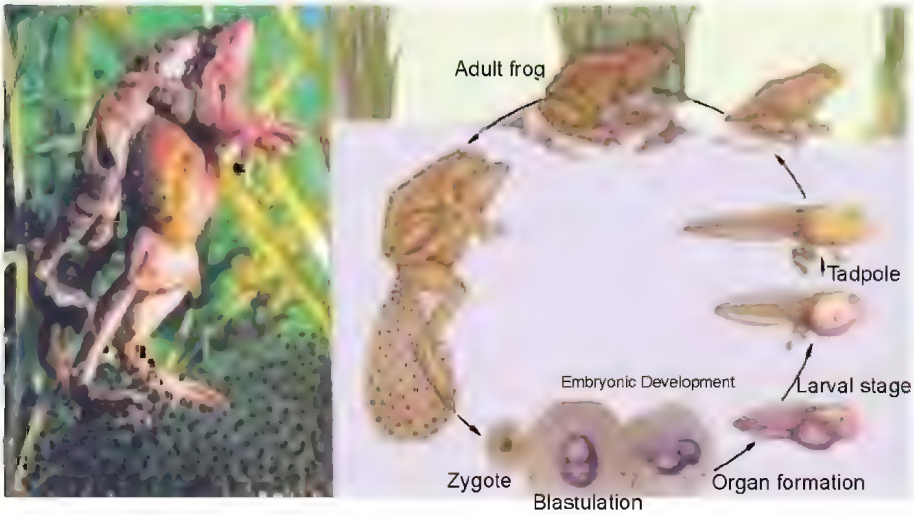


Figure 3.35 Reproduction and life cycle of frog (for study)

Reproductive System in Human

As the case in most vertebrate the sexes in human also is separated, the reproductive system in human is more complicated than other vertebrates; we will study the parts of male and female reproductive system and the function of each one.

Male reproductive system in Human

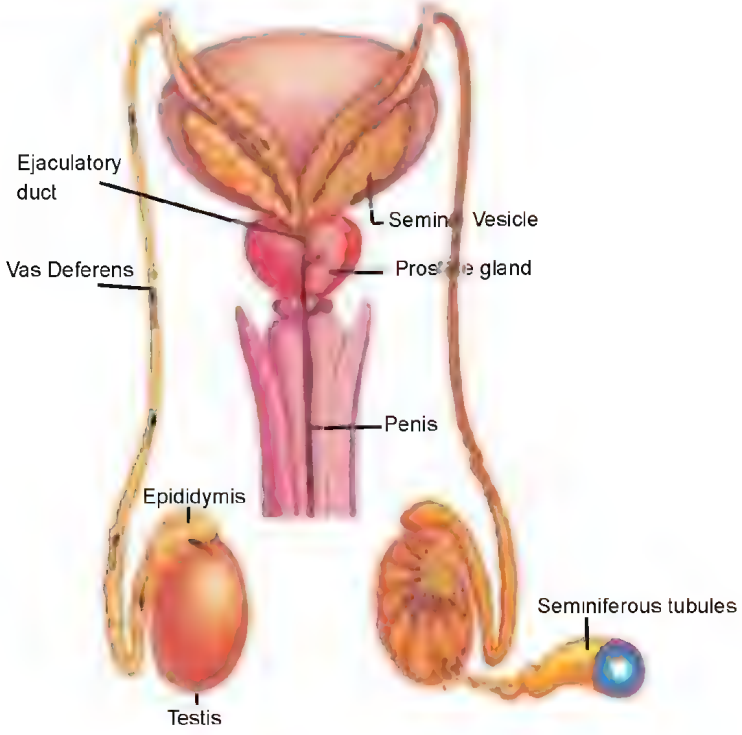


Figure 3.36 Male reproductive system in human

Male reproductive system in human consist of reproductive organs and accessory glands.

ORGANS	FUNCTION
A. REPRODUCTIVE ORGANS	
1. Testes (2) they are located in Scrotum outside of the body to perform their function at available temperature.	Produce sperms and sexual hormones.
2. Epididymis (2)	The place to store the sperms.
3. Vas Deferens (2)	Sperms movement.
4. Ejaculatory Duct (1)	Delivers the sperms to the penis.
5. Penis (1)	Intercourse organ.
B. ACCESSORY GLANDS	
1. Seminal Vesicle (2)	Secretes liquid to the sperms and its secretion makes big part of semen liquid
2. Prostate Gland (1)	Secretes some of semen liquid
3. Bulbourethral Glands (2) also called Cowper's Glands.	Secretes mucus liquid helps the sperm to move also helps to equalize the acidity of the liquid which the sperms get produced

Table 3.3 Explains content of male reproductive system and function of each one

Sperm Formation

The testes in human is an oval shape it contains **seminiferous tubules**, and the length of seminiferous tubules all together is about **250** meters.

In the seminiferous tubules **spermatogonia** forms which will increases in size and divides normal division to form two **primary spermatocytes** and both of these cells are bi –chromosome group (**2n**).

Primary spermatocytes undergo meiosis to form secondary spermatocytes and these cells are haploid chromosomes group (**n**), followed by second meiosis division to produce **early spermatids** which are haploid chromosome group (**n**), and these differentiate to form sperms which is also haploid chromosome (**n**).

Mature sperm differentiates into three parts: **head**, **middle piece** and **tail**, the head consists of nucleus and a head cover which contains the **acrusome** in the front part, it is thought that the function of acrosome is forming materials with enzyme nature, the egg membranes get dissolved by this material in the area which sperm meets the egg so this facilitates the passing of sperms to the egg surface, and the middle piece contain an axil of longitude tubes, it is believed that it controls the movement of the tail.

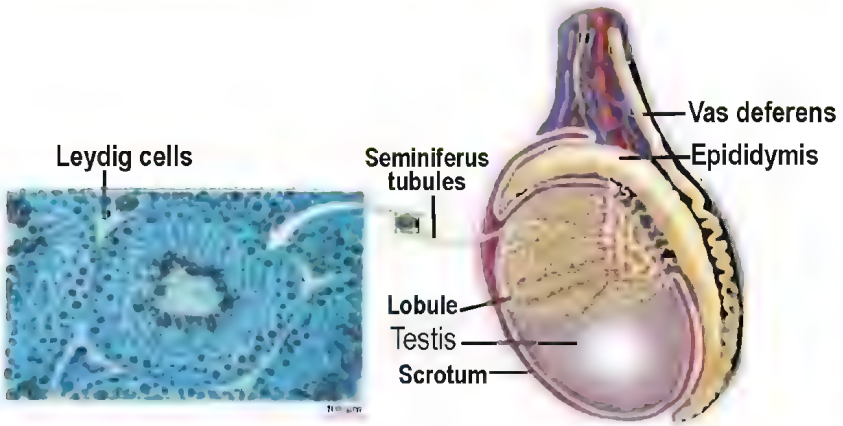


Figure 3.37 Testis structure in human (for study)

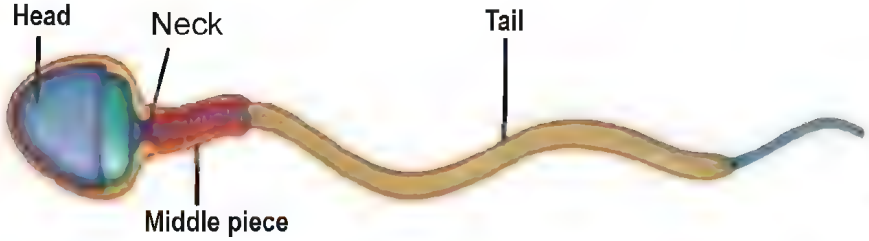


Figure 3.38 Mature sperm in human

2- Female reproductive system in human

Female reproductive system in human consists of two ovaries, two oviducts, uterus and a vagina.

The ovaries contain thousands of eggs and they are usually smaller than the testes, each egg grows inside a follicle called **graffian follicle** and this grows and increases in size, until it explodes in the end to release the mature egg. During woman's fertility period, about 13 eggs get matured every year, so about **300-400** eggs only gets a chance to be mature and the rest of the eggs are dissolved and absorbed.

The two **oviducts** are called **Fallopian tube** these tubes to carry the eggs, the front part of them has funnel shape openings to receive the eggs which it releases from the ovary after ovulation, oviduct has a fimbrea lining to push the eggs in its way.

Oviducts open in the upper sides of **uterus,** which specified to keep the embryo during the nine months while staying inside the uterus.

The uterus has a thick muscular lining, and a lot of blood vessel and specialized lining.

Vagina, this is represented by a muscular tube ready to receive the embryo after it exits from the uterus; it's also specialized to receive male organ during the intercourse.

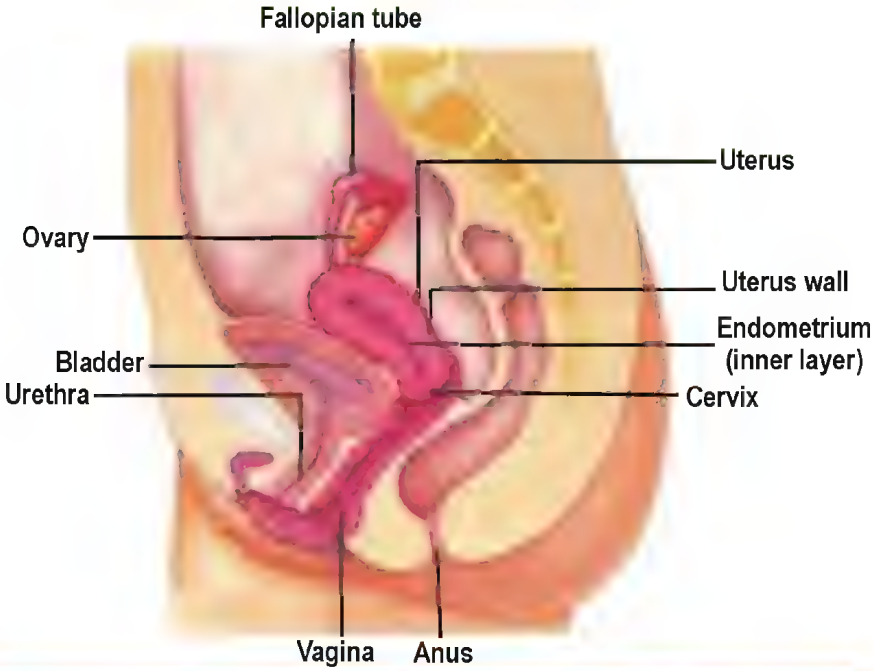


Figure 3.39 Female reproductive system in human (for study)

ORGAN	FUNCTION
1. Ovaries (2)	Producing eggs and they get mature in it. also produce sexual hormones
2. Oviducts (2) This is called Fallopian Tube	Transferring the eggs from the ovary to the uterus and usually the fertilization of eggs takes place in it.
3. Uterus (1)	It is the place where the embryo grows.
4. Cervix (1)	It secretes mucus material to help sperms to move inside the uterus. After fertilization it protects the embryo from bacterial infection.
5. Vagina (1)	It is the female intercourse organ.

Table 3.4 Female reproductive system and their function in human

Fertilization and pregnancy

Fertilization takes place when the sperms enter to the vagina during the intercourse between male and female at or near the ovulation time.

The sperms swim from vagina towards the cervix then enter into the uterus then ascend to the Fallopian tube, where the fertilization takes place if there was a live mature egg in the upper third of it. If mature egg descended to the lower part of fallopian tube before the fertilization it loses its ability for fertilization.

The mature egg gets fertilized by one sperm only, after fertilization the **zygote** formed in the fallopian tube, and then it starts to go down until it reaches the uterus where the embryo is implanted in the thick lining of the uterus. Embryonic membranes grow to form a sac which surrounds the embryo and it contains **amniotic fluid**.

At the end of implanting the embryo to the uterus lining pregnancy stage will start and the **corpus luteum** continues to secrete **progesterone** hormones after the 26th day of menstrual cycle until the fifth month. So it lacks the ability to form enough amount of this hormone to continue the pregnancy, the placenta replaces, and it works as endocrine gland to give enough amount of progesterone hormones to the lining of uterus directly instead of secreting it to the blood.

The embryo will be ready for birth after about 9 months of the beginning of its growth. Before the birth the placenta will stop to produce progesterone hormones, the uterus starts to contract, and this is the first sign to start the birth, then the cervix expands and the sac which contains the fluid will split. Then the liquid comes out and the uterus starts to contract strongly and consequently to push the baby outside the uterus through the cervix then to the vagina and then to outside of the body.

The size of the breast in women increases during the pregnancy, the milk gland secretes the milk as a respond to the effect of the hormones.

Menstrual Cycle

In the reproductive system of sexually mature female, periodic changes happens, these changes start when the female reaches the adolescence age **12-14**, these changes happens within **menstrual cycle**.

Menstrual cycle includes changes happens in the ovary which leads to ovulation and explains the main roles for ovulation and the growth of ovarian follicle, and also changes in the lining of the uterus, the table (3·5) explains the events of **ovarian cycle** and **uterine cycle**.

1-Ovarian Cycle

The Ovarian cycle is controlled by **Gonadotropic Hormones, Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH)**, we summarize the events of ovarian cycle as the followings:

a. Early Follicle forming stage; It contains oogonia which are diploid **(2n)**, and the first meiosis starts.
b. Primary Follicle forming stage; A non-cellular membrane called **zone pellucida** starts to forms around the egg.
c. Secondary Follicle stage, the vacuole of follicle appears with full of secretions from the follicle cells, blood plasma contents, protein and others.
d. Mature follicle stage, the follicle gets mature and the first meiosis completed, the secondary oocyte and a primary polar body forms.
e. Ovulation stage, the follicle splits, then the secondary oocyte and first polar body releases.
f. Corpus Luteum formation stage, Corpus luteum forms from the follicle remaining. (The Corpus Luteum dissolves when the woman is not pregnant).

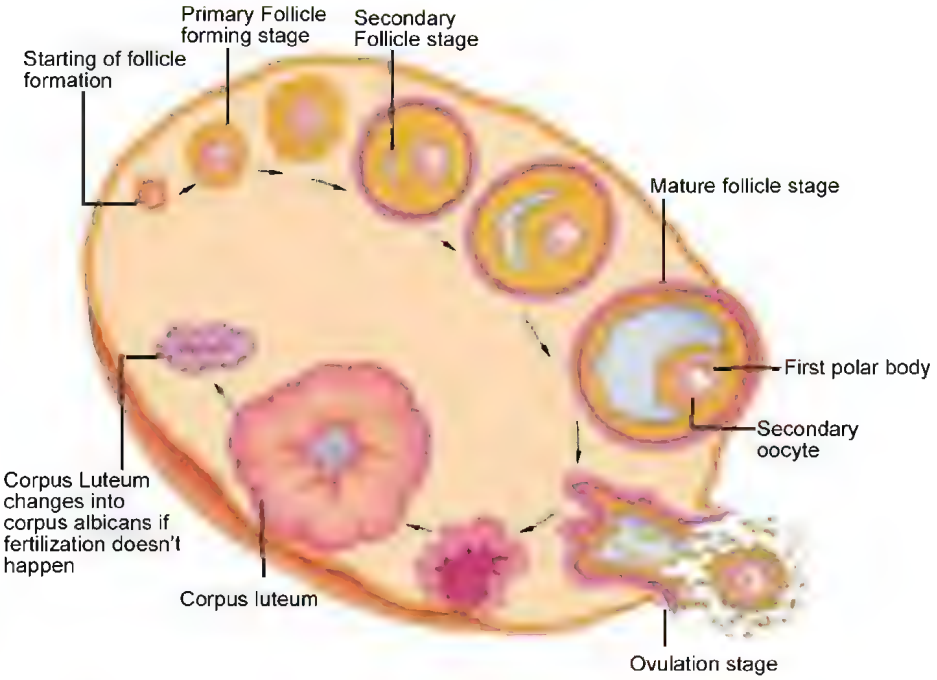


Figure 3.40 Ovarian cycle stages in sexually mature human female

2- Uterine Cycle

Female sexual hormones in the **ovarian cycle** produces **estrogen** and **progesterone**, these hormones effects the internal lining of the uterus **endometrium** and this causes periodic events called **uterine cycle** the period of this cycle is 28 days and it divides as the following:

1. Between the days **1-5** the level of sexual hormones is low, this leads to tear the lining of the uterus and its blood vessels, and the blood comes out by the vagina during the monthly period.

2. Between the days **6-13** the ovarian follicle will increase producing oestrogen hormone, the internal lining of the uterus thickness and becomes rich with vessels and glands, this called reproduction stage, the ovulation usually takes place in the day **14** of the **28** days of cycle.

3. Between the days **15-28**, the corpus luteum increase producing progesterone hormone causing double increase in thickness the lining of the uterus and increasing uterine glands which produces mucus secretion, this called secretion stage of the menstruation cycle.

The internal lining of the uterus in this case will be ready to receive the embryo. And if there isn't pregnancy, the corpus luteum disappears and the level of sexual hormone decreases in female's body and the internal lining of the uterus tears, then the monthly period takes place.

UTERINE CYCLE		OVARIAN CYCLE	
Stage	**Events**	**Stage**	**Events**
1. Menstrual cycle days (1-5)	The internal lining of the uterus tears	1. Follicle stage days (1-13)	-Produce follicle stimulating hormone (FSH) -Produce estrogen to mature the follicle
2. Forming stage days (6-13)	The internal lining of the uterus repairs itself	2. Ovulation stage days (14)	Decreases production of luteinizing hormones (LH)
3. Secretion stage days (15-28)	The internal lining of the uterus thickens and the glands get mature secrete its secretion	3. Corpus luteum stage days (14-28)	Secretes follicle stimulating hormone (LH) to form the corpus luteum which secretes the progesterone

Table 3.5 Ovarian cycle and uterine cycle in human

Parthenogenesis

Parthenogenesis is type of reproduction which the embryo grows from non-fertilized egg. This kind of reproduction happens in the aphids, insects and in many kinds of fishes, amphibian and desert lizards.

Parthenogenesis is common in honey bees, the female of bee or the queen gets fertilized by the male once in its life. It keeps the sperms in a sac which is connected to the reproductive passage, closes by muscular valve, when the queen bee lays her eggs, it opens the valve to release the sperms, so these sperms fertilize the eggs or it keeps it closed,the eggs will grow without fertilization and the fertilized eggs become male.

In some cases the parthenogenesis is the only type of reproduction, there are certain gathers of Whiptail lizards which lives in south-west of America and their individuals are female and these females are diploid (2n). So, because their chromosomes doubles it self before meiosis division to be **tetraploid** chromosome (**4n**) and after the division it becomes diploid, these eggs which are diploid grow without fertilization .

Hermaphroditism

Many types of animals has male and female reproductive organs in the animal, this kind of animal called **hermaphrodite**, therefore the one animal produces eggs and sperms, usaully most of hermaphroditic animals avoids self fertilization but **tapeworm** have ability to fertilize itself (**self fertilization**).

Although it has male and female reproductive organs at the same time, but it fertilizes its eggs by sperm of conjugated animal or vice versa. There are some hermaphroditic animals avoid self-fertilization because growing and maturing of eggs and the sperms in different times. On the other hand the tape worm has the ability to do self-fertilization, so its sperms fertilize its eggs.

Hermaphroditism has different shapes in many invertebrate animals like some hydra, flat worm, annelids and some types of scale. It seen in some kinds of fishes but rare in other vertebrates.

Review

Q.1 Write the suitable scientific term in each of the following

1. ..... cells which are produced by mitosis from the primary germ cells which are lined for the seminiferous tubules.
2. ..... unicellular organism is from green algae, and its green cell has got two flagella.
3. ..... it is egg shape or cylinder sac structure and it has pollen inside it.
4. ..... has a green colour heart shaped structure and carries Archegonium and Antheridium.

5. ..... are expanded stems store the food and grows under the ground.
6. ..... is vegetative propagation method, the branch remains connected to its mother and it buries under the ground.

Q.2 Mention the location and the function of the following.

Acrosome, Interstitial cells, Corpus luteum, Accessory glands, Prostate glands, Fallopian tubes, Sporophyte, Stigma, Micropyle, Torpedo stage.

Q.3 Compare between the fallowings.

1. The donor cell and the recipient cell in sexual reproduction of bacteria .
2. Archegonium and Antheridium.
3. Sepals and Petals.
4. Cross pollination and Self-pollination.
5. Artificial fruits and natural fruits.
6. Compound Fruit and aggregate Fruit.
7. Reproduction by stolons and reproduction by Rhizomes.
8. Oviparous insects and ovoviviparous insects.
9. Conjugation and self –fertilization in Paramecium.

Q.4 Complete the followings.

1. The sperms form in .....which consist of big number from.....
2. Reproduction in viruses happens through two integrated cycle first one is .....cycle and..... cycle
3. Paramecium reproduces sexually by .....and.....
4. Anthocyanin pigment accumulates to mature fruit as in ..... and .....
5. The ideal life cycle in hydrozoa are in two stages..... and.....
6. Planaria reproduces sexually by.....
7. The reproductive organs insects are two parts .....and .....
8. The length of seminiferous in human testes is.....
9. Mature sperm in human divides into three parts are....., ...and.....

Q.5 Define the following scientific terms.

Double fertilization, multiple fruits, pollen tube, nuptial pad, Graffian follicle, parthenogenesis.

Q.6 Choose the correct answer for each of the followings.

1. Hydra reproduces in many ways except:
a-budding c-fission b-regeneration d-gametes

2. Alternation of Generation appears in life cycle of:
a-Bacteria c-Amoeba b-Plasmodium d-Polytrichum

3. The number of spermatids that formed at the end of spermatogenesis is:
a-(4) c-(6) b-(2) d-(8)

4. Bacteria reproduce asexually by:
a-Budding c-Regeneration b-Binary fission d-Spores formation

5. Paramecium reproduces asexually by:
a-Binary fission c-Budding b-Regeneration d-Spores formation

6. Which one of the following organisms doesn't reproduce asexually by binary fission ?
a-Paramecium c-Euglena b-Bacteria d-Black bread mold

7. Hydra reproduces asexually by:
a-budding and binary fission
b-budding and fragmentation and regeneration
c-spores formation and binary fission
d-fragmentation and regeneration

8. The shape of leaves vein in the plants with double split is:
a-netted c-vertical b-parallel d- crossed

9. One of the following organisms reproduces by fragmentation and regeneration:
a-Planaria c-Bacteria b-hydra d-none of them

Q.7 Write a summary about each of the followings:

1. The role of the bees in plants pollination.
2. Cleft grafting
3. Male reproductive system in frog

Q.8 Write what you know about the followings:

1. Explain the steps of asexually reproduction in bacteria by a diagram.
2. Alternation of Generation in plants reproduction.
3. The steps of tissue transplantation for the date palms.

4.The events of uterine cycle in human female.

Q.9 Explain what happens in the following cases:

1. Disappearance of corpus luteum in forth month of pregnancy.
2. The location of testes inside the human body.
3. Absence of cilia in the lining of fallopian tube.

Q.10 Explain by a diagram with writing the data:

1. The stages of sperm formation.
2. The three layers of the fruit.
3. Reproductive system in Planaria.
4. Male and female reproductive system in insects.

Q.11 Justify and explain the following facts (write causes):

1. Reproduction enables the survive of species.
2. Alternation of Generation is the best way for reproduction.
3. Only some members provide reproduction process in some species.
4. In asexually reproduction some organisms disappear when the environmental conditions available.
5. Human usually uses artificial fertilization.
6. Production large number of pollen grains.
7. Presence of micropyle in the ovary and the seed.
8. Presence of Cowper gland, prostate gland and seminal vesicle in the male reproductive system.
9. Viruses are able to grow and reproduce inside the living cells, but it loses this ability outside.
10. The tail of virus secretes enzyme when attaches to the bacterial cell.
11. The farmers advise to have bee hives in their farms.

CHAPTER 4
Embryonic Development

Contents

Objectives

1- Define the concept of growth.
2- Define the concept of cellular differentiation.
3- Determine the levels of organization in animals.
4- Summarize the most important theories of Embryology.
5- Define the term of Cleavage.
6- Define the term of Gastrulation.
7- Explain the stages of embryonic growth of Amphioxus.
8- Identify the factors lead to congenital malformation in human.
9- Identify the types of twins.
10- Define the Stem cells and their types.
11- Explain the concept of cloning.

Introduction

Embryonic development or the growth is worth to give attention. In many cases it leads to wonder, so how is the tiny human egg, Its diameter is one hundrend micrometer and it is not seen by naked eye becomes a complete organism which consists of billions of cells and each group of them achieves functional role. Embryonic development includes **growth,** and **differentiation** which are basic characters of life.

The question is "How the formation of complete organism can be performed from single cell?"

To answer this question, we say, all the necessary information is available inside the zygote, mainly in the genes of nucleus. All the stages of embryonic development controlled by **DNA** particles which located inside the zygote.

Concept of Growth

Growth can be defined as an increase in size and weight of cells of organisms. The tissues are made up from a large number of cells which play the main role in the stages of growth, the growth of the organisms occur by one of the following methods:

1-Growth by cell reproduction or cell duplication, that's achieved by forming new cells by division.

2-Interstitial growth, this kind of growth means is the increase in the cellular substance which found in construction of tissues as intercellular substance in connective tissue. Hyaline cartilage cells grow and differentiate into mature cartilage cells which secrete interstitial substances. This forms the base material of hyaline cartilage tissue. This represented by **chondro-mucoprotein** so the cartilage grows by increasing its interstitial substances.

3- The growth of a single cell: this kind of growth is rarely happens, it is growth in size of the cells, for example the growth of nervous cells; it increases in size and multiples of the original size. That's because the increase in the size of cytoplasm through new organelles formation, and also the growth of **dendrites** in the nervous cell which increases the surface area of the cell.

Concept of Cell Differentiation

Cell differentiation is defined as the ability of embryonic cells in the early stages of embryonic development to get functional ability, this means functional ability of cell or a group of cells which other cells can't do it. For example contraction in the cell or fiber muscle is special functional trait for muscular cells, can't any other cells do it, and also secretion which happens in the glands cells.

Although there are some recognized factors which play roles in directing some cells in differentiation but the procedure of differentiation is not understood completely.

Level of Organization in Animals Complexity

Complexity is regarded as one of important characteristics in history of animal development, so the simplest unicellular animals have much more narrow field in complexity level. Despite of that, these animals are complete organisms and they do all the main vital activities which the more complex animal do it. Animals show five level of organization, and they are ordered in a way so each one of them is more organized than the previous one as following:

A-Protoplasmic level of organization

Protoplasmic organization is clear in unicellular organisms as Protista. In these organisms all the vital activities take place inside the one which represents the main unit of life. In the protoplasm of the cell some organelles specialized to do special functions.

B- Cellular level of organization

In this level of organization we see division in the function, that some cells are specialized for reproduction and others for nutrition as in colony of volvox.

C- Tissue level of organization

In this level of organization, the identical cells group gather to form a tissue. Scientists think that sponges belong to this order in level of organization.

D-Level of organized tissues

Organization and mostly the organs are made up of more than one type of tissues, so it has a function which is more advanced than other types of tissues. This level of organization starts in flat worms, which has a number of limited organs like proboscis and reproductive organs.

E-Level of organ system

In this level, the organs work together for a certain function, reaches to the highest level of organization which is organ system, the systems do the main function for the body, like blood circulation, respiration, digestion, and others. Organization shows the top level in human which is at the top of the development pyramid of the organisms.

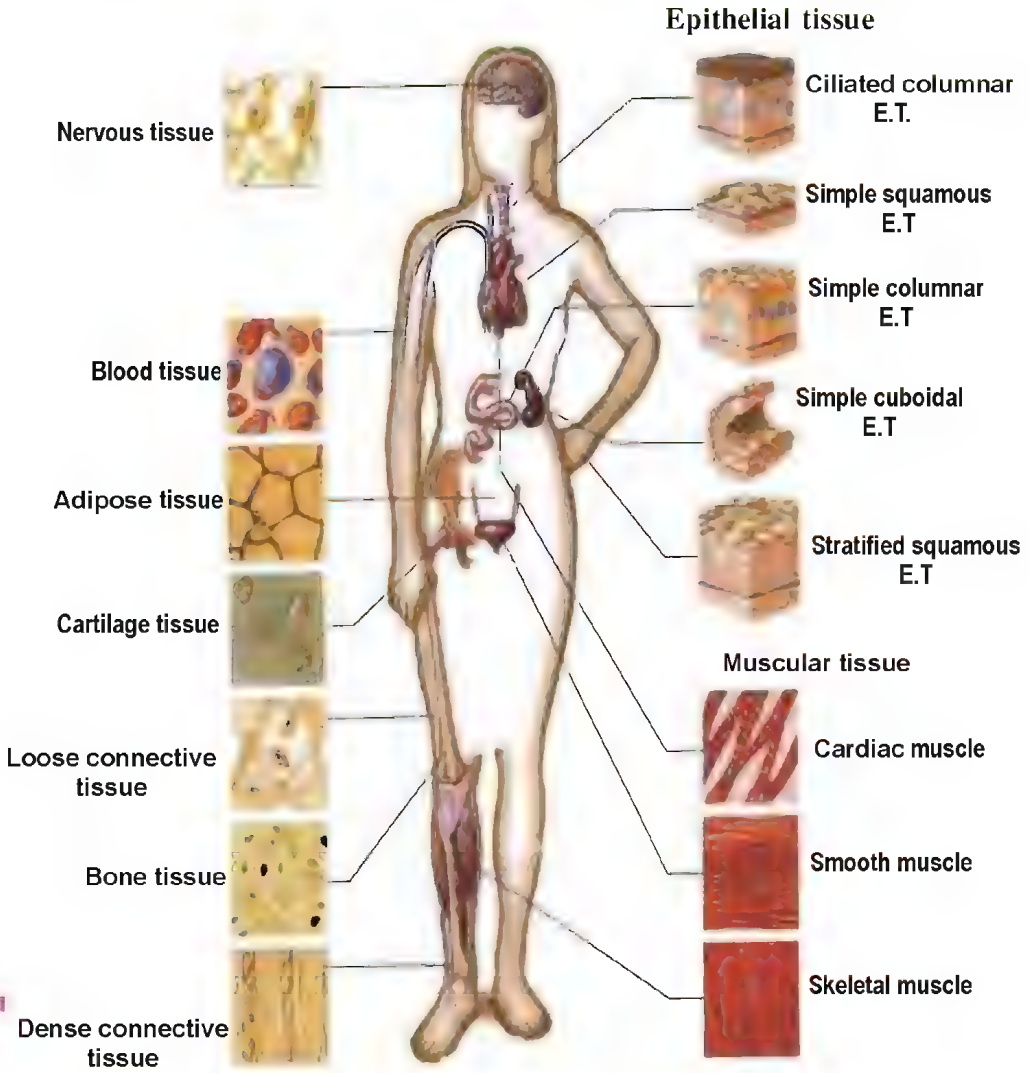


Figure 4.1 Tissues in human body (for study)

Concept of embryonic development

Embryonic development defined as forming the organism from one cell which represented by zygote, until formation completed to become a multi cellular complicated structure, similar to the parents.

Embryology is the science which studies the embryonic development which includes the **growth** and **differentiation** and **development**

During the process of embryonic development, **morphogenesis** take place, which is appearance forming of the embryo; the main steps of this process are similar in embryos of all vertebrates. It is necessary to point out that focusing only on embryo development is insufficient which represents Pre-metamorphosis in amphibians, and pre-hatching stage in birds, the stage of pre-birth in embryonic animals, but it continues to other stages involves the growth of the animal in living stages, for example in embryo of the frog after the organs formation.

After the hatching, the tadpole doesn't look similar to the parents; it undergoes the stage of **metamorphosis** which includes quick changes in the body. So the tadpole with tail which feeds on plants in water changes to a small frog which feeds on meat on the land. **Metamorphosis** happens in insects too, in the mammals the new born is similar to the parents, the first step in the growth of the new born start, so cartilage replaced by bones, and these bones continue growing for a certain time, also some organs not perform its functions functions for a certain time for example **ovaries** and **testes** in human.

Opinions and Theories about Embryonic development

Embryonic development has taken scientists and researches attentions since long time, and their first question was;

What was the procedure which controls forming a new organism that is similar to the parents?

The scientists were unable to explain many points in the formation of embryo, as human creation is the secret of human existence.

In the following there are concepts and theories about embryology:

1. The Greek philosopher **Hippocrates** in the 5th century (B.C.) established the first qualitative notes about embryonic development for chicken, and then followed him the Greek philosopher **Aristotle** (350 B.C.) who is regarded as the embryology founder. described embryonic development for the chicken, at so mentioned that the parts of the embryo is formed according to the egg contents, he relied on his sight in this description by that he found **Descriptive Embryology**.

2.When the scientific method was approved in the explanation of natural phenomena in the 17th and 18th century, the science developed including embryology. After discovering the microscope, the scientist **De Graaf** in (1672 AC) introduced a description for **ovarian follicle**. The scientist **Leeuwenhoek** described the sperm in (1677 AC) the ideas established which had role on the progress of embryology.

Figure 4.2 Homunculus inside sperm cell (for study)

3. Pre-formation Theory: The supporters of this theory assumed that there is a minimized embryo inside the egg called **Homunculus** and its parts get bigger when stimulated by seminal liquid. The attitude of these scientists was proved when the scientist **Bonnet** in (1745 AC) explained the ability of some eggs to grow by **Parthenogenesis** without fertilization in some insects.

The other **Pre-formation Theory** supporters group assumed that there is **homunculus** in sperm's head, so they proved that seen homunculus was inside sperm's head by using Leeuwenhoek microscope.

Then the scientist **Spallanzani** explained that forming new organism needs male gametes and female gametes.

4. Epigenesis Theory: this theory assumed that the embryo is made of a granular material inside the egg and it turns gradually into an embryo and this theory belongs to scientist **Wolff.**

5. The scientist Karl Ernst Von Baer set the **"Von Baer Law".** This scientist pointed out that the general characeristics in the embryo of chordata appear before the specialcharaceristics in the animal of that group, for example the appearance of notochord in the embryo of chordata before the appearance of the characeristics which specializes the types which belongs to the chordata like growing the feathers in birds.

Von Baer is one of the scientists who did a lot for embryology. He compared the embryonic development in different animals in his studies which named as **Comparative Embryology.**

6. Experimental Theories: these are the theories depends on having experiments to explain embryoinc development.Scientist **Roux** (1888) is the first one who did an experiment on the egg of frog in the first cleavage stage by killing one of the blastomeres by very hot needle. The formed embryo was incomplete and then the embryology entered into a stage called **Experimental Embryology.**

Experimental embryology led to discover the **Embryonic Induction** in the thirties of the last century. Which means, the ability of certain tissue to differentiate after receiving the induction signals which make it ready for differentiation, for example the differentiation of Ectoderm cells after receiving the induction signals from lower tissues to change the neural plate which the nervous system forms from it. This phenomenon was discovered by the scientists **Spemann** and **Helda Mangold** who did many experiments on the embryo of frogs, the scientist Spemann got the Nobel prize in (1935 AC) for his experiments, and then the scientists started to give a big intrest to bio-chemistry and physical chemistry in their experiments. Then the Experimental Embryology transferred to the level of molecule then the **Molecular Embryology** appeared which explains the phenomenon of embryoinc development according to the role of bio chemistry by using special machines.The Electron Microscope had special importance in that.

It is necessary to mention that in current time that **Preformation Theory** can be accepted that, all information regarding the embryoinc development already determined and carried on the DNA. Also acceptance of **Epigenesis theory** regarding those different organs of embryo forms epigenetically gradually.

Main concept of Embryonic development

Embryology doesn't stop at the end of each stage of formation, but continues to the next stage, to explain the embryology we divide it as the following:

1-Formation of Sex cells and Fertilization

This stage includes:

a- Formation of **Gonads** which are able to form reproductive cells.
b- Producing the reproductive cells when organism reach the sexual maturity.

c-Uniting of the ovum and the sperm by fertilization and forming the **Zygote.** Fertilization is not the end of sexual reproduction but it is the beginning of a chain of systematic and completed changes which produces new individual belongs to the same species.

2-Cleavage

It is a chain of frequent mitotic divisions which start from **Zygote** and divides into two cells (**Blastomeres**) and then into four blastomeres then into eight blastomeres and by frequent divisions. The zygote changes into a hollow and ball shaped group of cells called **Blastula,** the thickness of it is one layer of cells as in Amphioxus which is from prochordata, or a half-hollow ball and the thickness is many layers of cells as in amphibians (frog), or becomes a group of cells in shape of **blastodisc** which is settled on one of the egg's poles as in birds and reptiles.

3-Gastrulation and formation of Germ Layer

This is regulating cells according to **Morphogenetic Movements,** so the embryo in this stage is complicated cellular structure called **Gastrula** which forms two germ layers in the embryo of invertebrates and protochordata. So the embryo is consisting of two layers; **Ectoderm** and **Mesentoderm. Gastrula** can be triple layers in other embryos of chordata and the embryo consists of **Ectoderm** and **Mesoderm** and **Endoderm**

4-Differentiation

In this stage the cells would take certain direction in the operation of embryonic development. So the cells differentiate in the shape which is suitable with the type of function it does, as in nervous cells. It transfers the nervous signals therefore **Histological Differentiation** happens in it which represented by acheiving the function through **axon** and **dendrites.**

5-Organogenesis

It is the stage of embryo growth and organizing the cells in the form of tissues, and the tissue is in the form of organs that formed through organ differentiation during embryonic development. So the three germ layers differentiate to four main types of tissues they are Epithelial Tissues, Connective Tissues, Muscular Tissues and Nervous Tissues.

6-Stage of Post hatching

It is the stage which the embryo comes out from the egg, as in most fishes, all the amphibians, most of the reptiles, all the birds and some mammals, or by the birth as in some fish, some reptiles and most mammals. At the end of this stage the process of **Sexual Maturity** starts which ends up by sexually mature animals (male and female) which conjugate and so on.

Embryonic Development in Amphioxus

Embryonic development in Amphioxus has been studied to know the process of embryonic development in a clear way because it represents the simplest way.

These processes regarded as the base for embryonic development in the animals that are more developed than Amphioxus which belongs to protochordata. Therefore studying its embryonic development represents connection point between the embryonic development stages for vertebrate and invertebrate animals.

The two sexes are separate in Amphioxus. The gonads (testes or ovaries) located on both sides of abdominal cavity, and no ducts exits out of the gonads, so the gametes exit at the sexual maturity into **Atrium** and then the body through **Atriopore** into the water media, so the eggs get fertilized by the sperms at the outside.

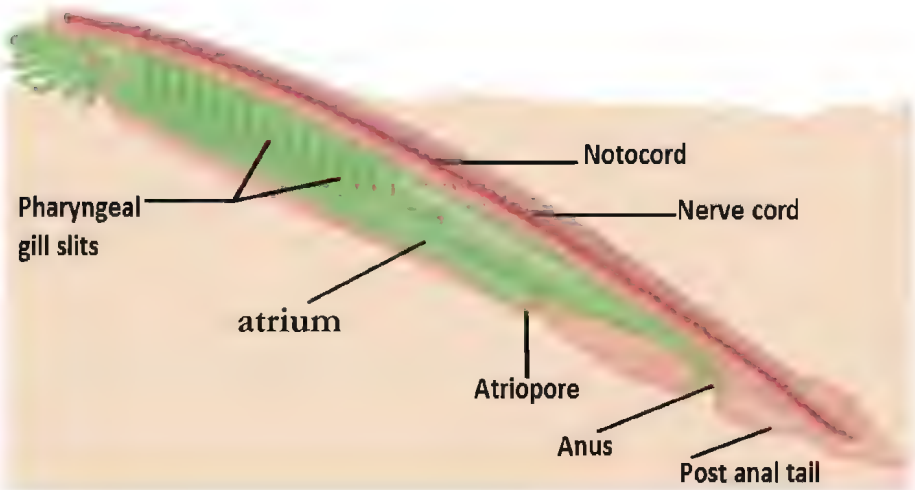


Figure 4.3 Morphological structure of amphioxus

1- Gametes

Male gametes sperms consist of three main parts; **head** which is a sphere shape, then the **middle piece** which is short and the **tail** which is long. The egg of Amphioxus is small in size and its diameter is **0.1mm** and its (**Microlecithal**) granules of yolk spreads not quite identically in the cytoplasm, the yolks granules is less concentrated at the **Animal Pole**. They are more concentrated at the **Vegetal Pole** which is at the opposite of it, and also the area of animal pole has got a nucleus and the egg gets covered by **Vitelline Membrane**.

2- Fertilization

Fertilization in Amphioxus takes place externally, the sperm penetrates the egg and the fertilization takes place by uniting the male nucleus with the female nucleus to form the zygote and an adaptation happens on zygote surface which prevents entering other sperms inside the egg.

3- Cleavage

About one hour after fertilization, the first cleavage starts by appearance the furrow of cleavage from the animal pole gradually descends towards the vegetal pole, and its level is longitudinal, at the same time the nucleus of the zygote divides into two nuclei, each one of them heads towards one of the sides.

Then the zygote divides into two blastomeres (two cells) then the second cleavage follows it. Which its level is longitudinal too, but it is vertical on the level of the first cleavage and its products are four equal sized blastomeres this is followed by the third cleavage which is latitudinal just above the equator of the cleavages towards animal pole, this is because the yolk is available in vegetal pole with higher concentration. The product of this cleavage is eight blastomeres the four upper blastomeres are called **micromeres** which are smaller in size than the four lower blastomeres which are called **macromeres**.

This is followed by the fourth cleavage which divides the eight blastomeres by two longitudinal levels to form sixteen blastomeres and then the fifth cleavage takes place by two latitudinal levels and the products are thirty two blastomeres .

This is followed by independent cleavages of each blastomere with keeping the size of blastomeres in the animal pole smaller than blastomeres in the vegetal pole, and the product of this is a mass of blastomeres which is similar to the berry fruit called the **morula**

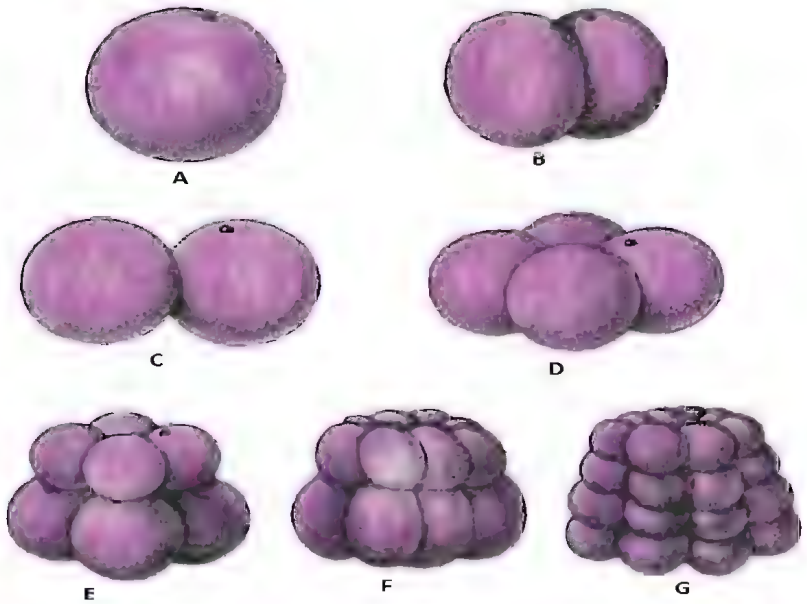


Figure 4.4 Cleavage stages in amphioxus(for study)

A) Zygote of amphioxus
B) First cleavage
C) End of first cleavage and two blastomere formation
D)second cleavage result in 4 blasts
E)third cleavage result in 8 blasts
F)fourth cleavage result in 16 blasts
G)fifth clevage result in 32 blasts

4-Blastulation

The division continues after the formation of morula to form spherical shaped structure called blastula which has one layer of cells surrounds a big coelom called **blastocoel** which starts appearing from eight cell stage as a very small coelom expands gradually by the progress of division, the blastula is recognized by the size of the cells in animal pole still smaller than the cells in the vegetal pole.

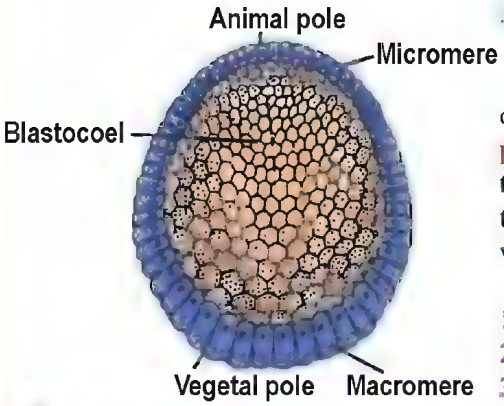


Figure 4.5 Blastulation stage in amphioxus embryo

5-Gastrulation

Gastrulation is another stage of embryonic development stages in Amphioxus and through this procedure a cellular movement takes place called **Morphogenetic Movements.** So the blastulation changes from mono-layer embryo to double- layer embryo in Amphioxus (Triple-layer embryo in the other vertebrates) called **Gastrula** which is regarded as **First Differentiation Phase** in which three kinds of different cells are determined:

1. Cells form **Ectoderm** which is externally located.
2. Cells form **Endoderm** which is internally located.
3. Cells form **Mesoderm** which is intermediate located (between the two layers).

These three layers called **Germ Layers** and these are the origin of all the organs which formed in the embryo of vertebrate. The formation technique of the Gastrulation depends on the type of the animal; it is less complexity in Amphioxus than the other vertebrates.

Formation of gastrulation in amphioxus starts when the cells of vegetal pole of blastula begin flattening and then invaginating. The **invagination** continues progressing to the inside toward to the non-invaginated part. So the size of **Blastocoel** decreases gradually and disappears when it touches the cells of vegetal pole with the cells of animal pole, and then it gets replaced with a new coelom called **Gastrocoel** or **Archenteron** which opens outside by a hole called **Blastopore**.

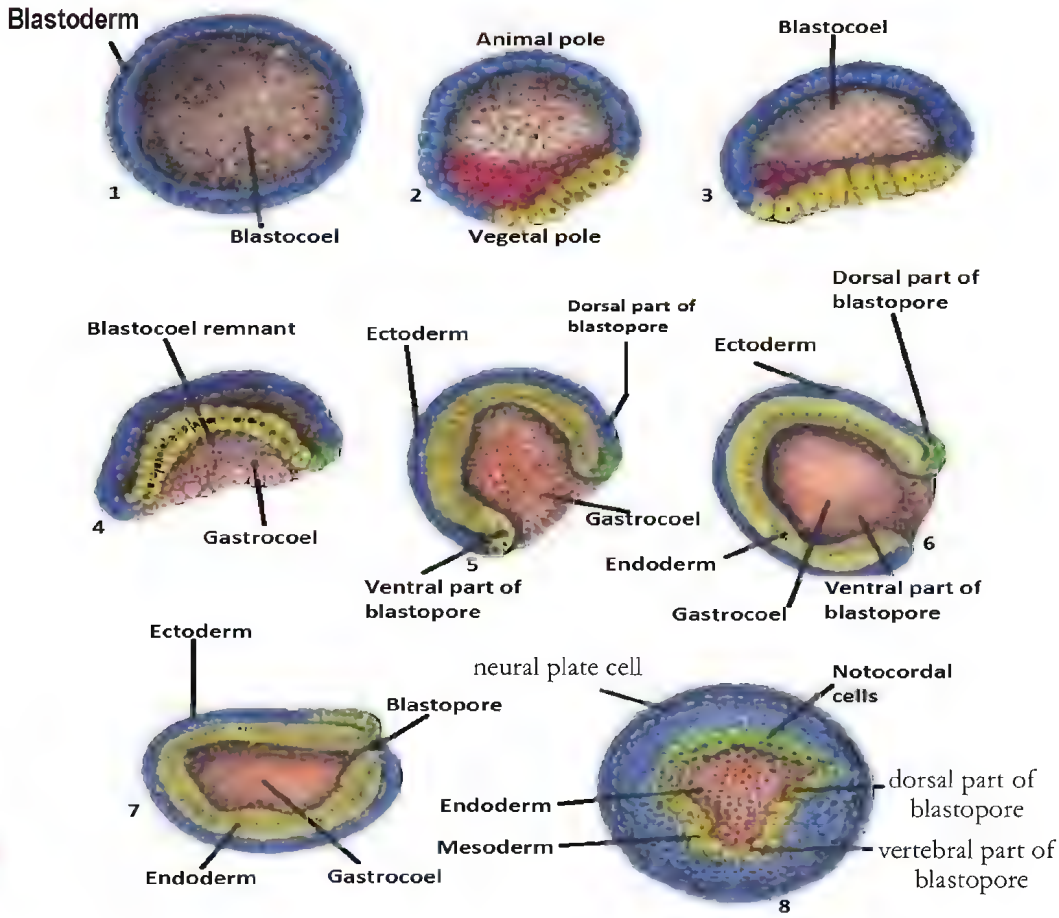


Figure 4-6 Gastrulation in amphioxus (for study)

Then the embryo is in a cup shape which consists of two layers, the external one called **Ectoderm** and the internal one called **Mesentoderm**, and the **Blastopore** will be surrounded by these layers. They are the back layer (upper) which its cells called **Notochordal Cells** which forms the notochord later and the lower layer which forms **mesoderm** and **endoderm**.

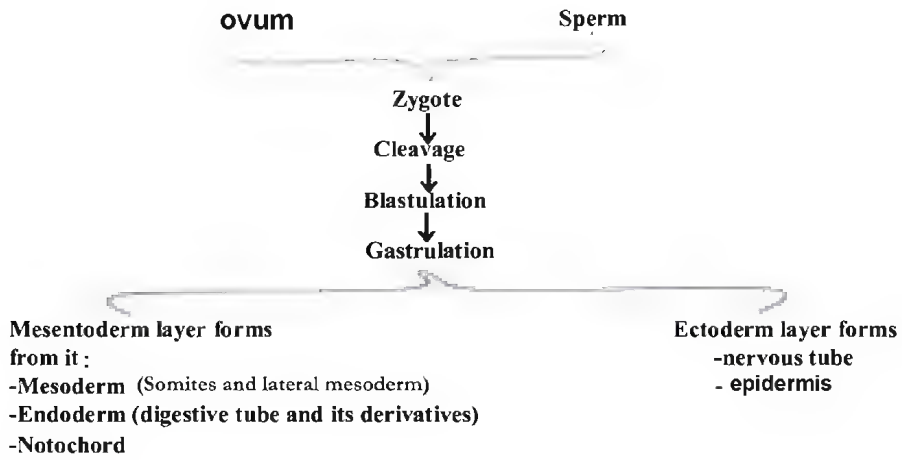
The Blastopore is wide in the beginning of gastrulation and then gets smaller gradually, and in the end of gastrulation changes into a small hole, that's because of embryonic movement in its surrounded layers.

As a result of pushing the cells of this layers inside, gastrulation which supports to form the internal layer of the gastrulation which includes the cells of endoderm, the cells of mesoderm and the cells of notochord, the remain cells in the surface of embryo represents the cells of ectoderm layer, then the germ layers forms and the gastrulation expands in amphioxus.

The gastrulation in amphioxus rotates around its axis, so the **Anterior-posterior axis** of embryo forms, so the side of blastopore represents the back end for the embryo, and the opposite side represents the front end for the embryo.

5-Organs Development in Amphioxus

The main organs in the Amphioxus initiate from the germ layers after formation are completed, and at the beginning of formation they are in a shape of pre-organs. Before considering the details of organs formation,we should know the derivatives of the germ layers in the embryo of amphioxus which is explained in the following diagram:



There are four main compottents in the body of Amphioxus:

1- Nervous System
2- Notochord
3- Mesoderm
4- digestive tract

A-Development of Nervous System

After the elongation of the gastrula , the cells at the dorsal region of the Ectoderm layer near the Blastopore migrate out, and this migration out extends on the entire posterior area and it becomes aband shape called **Neural Plate** this depress a little bit of the level of ectoderm. As a result of that the two edges of ectoderm rises, on the sides of neural plate and they join together above that, then the embryo becomes surrounded by ectoderm which forms the skin in the advanced stages of embryo formation in amphioxus.

At the same time the middle part of the neural plate invaginate to form the **Neural Groove** and the edges on the side of the groove called **Neural Fold** each fold faces towards the other one until they meet and join together then the **Neural Tube** is formed, which surrounds the **Neural Canal** or **Neurocoele** The formation of neural tube is called **Neurulation** and the embryo during this called as **Neurula**. After the formation of neural tube, their front parts differentiate into **Brain Vesicle** and the **Spinal Cord** follows it, which they represent the **Central Nervous System** in Amphioxus.

B-Development of Notochord

Notochord represents the internal structure of Amphioxus, and extends from the beginning of the head into the back end of the body. Notochord formed from the middle part of mesentoderm (the internal layer of Gastrulation) and these cells forms a groove called **Notochordal Groove** which closes up gradually when its sides gets near each other to form **Notochordal Rod**. This is a solid, non-coelom structure, separates from mesentoderm layer and changes into **Notochord** which is a cylinder shape, and supports in extending the embryo through the increase in the length.

C-Development of Mesoderm

During the formation of the neural tube, the mesoderm formed from the back side of the mesentoderm layer by a shape of two grooves which extend outside, and their coelom is connected with the coelom of the **Archenteron**, then on each groove horizontal partitions divide it into small parts. They are in shape of chain of **Archenteric Pouches**, and then these pouches separate from the coelom of archenteron and called as **Mesodermic Sacs**. These sacs grow on the side of notochord area, a coelom appears in it.

1-The upper part (back) of the sac represents **Somite** and this differentiate into three pieces which forms connective tissue under the skin, and the muscular piece which body muscles formed from it, and the solid piece which forms the surrounded wall of the notochord.
2- The lower part of mesodermic sac, and it called **Lateral Mesoderm** which differentiate into two layers, a layer located under ectoderm called **Parietal Mesoderm**, and a layer which is near to endoderm layer and it called **Splanchnic Mesoderm**, a coelom appears between the two layers. And then the lower part of right mesodermic sac meets with its left identical at the middle abdominal line for the embryo, by then their coeloms meet too, this will form one **coelom** for the body of the embryo.

D- Enteron Development

After Notochord and mesoderm get separated from mesentoderm layer, the remaining part of this layer represents **Endoderm** which its edges from the two sides grow towards the middle back line. Then they meet at the middle line, then Enteron, the intestine and its derivatives are formed in amphioxus and by the progress of the embryo development, the hole of the mouth and the anus forms.

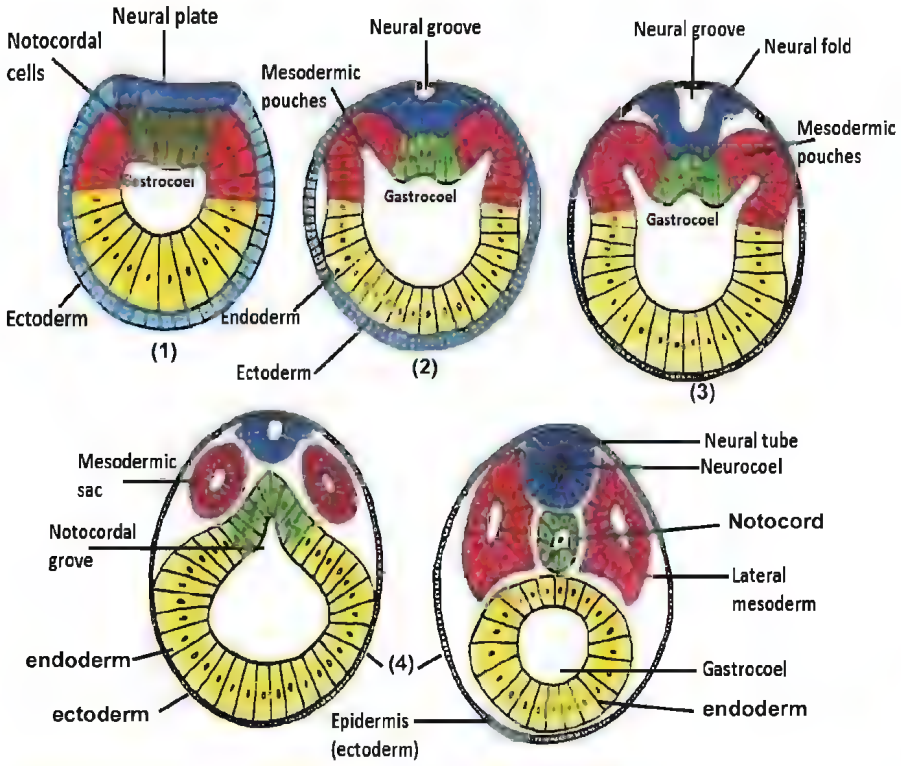


Figure 4.7 Cross sections from embryonic development in amphioxus explains the formation of Neural tube, Notocord, Mesoderm and Gut (for study)

Congenital Malformation in a Human

The embryo of human may dispose to congenital malformation. It represents the structural faults as a result of abnormal formation of the embryo organs or the body system and (**Teratologs**) takes care of that.

There are many factors causing the embryo malformation, this can be summarized in two main groups:

1- Genetic factors, including the exceptional of body chromosomes, as in **Down syndrome** which show malformation in the feature of the face, mental disorder and malformation in the heart.

2- Environmental factors, includes many factors, the most important one is the effect of radiation which causes many malformation such as malformation in the nervous system, direct exposure to radiation causes congenital malformation.

It is passed on to future generation and also exposure to radiation effects the fertility and causes partial or permanent sterility, this depends on the dose of radiation and exposal period of time and the age of the person.

Drugs are one of the factors that cause many embryo malformations such as malformation in the nervous system and the skeletal system, split lips, cleft and others. For that reason pregnant women should not take drugs without doctor's permission.

The first weeks of pregnancy is regarded as a critical period of embryo development.

The embryo is connected to the mother by **Placenta** inside the uterus, which helps transferring the food, oxygen and the other material from the mother to the embryo, so whatever the mother eats or gets any infection or illnesses it goes to the embryo. So the mother harms the embryo if she doesn't take care of her health, the mother should take care of some issues so the embryo does not get affected:

1. To avoid smoking because it affects the child's weight and causes a decrease in oxygen levels and raises the carbon monoxide level in both the mothers and the embryos blood and the placenta which causes an unhealthy environment for the embryo. Smoking also causes an increase in miscarriage and premature birth or embryo death, the effect of smoking continues beyond the birth of the baby causing infections in trachea, and asthma and others.
2. Reduce taking caffeine in coffee because over taking it harms the embryo.
3. Avoid taking the herbal medicine without doctor's consultation.
4. Alcohol affects the embryo; it causes nervous disorder and body malformation especially in the face, also behaviour disorder, and alcohol cause **Fetal Alcohol Syndrome** which appears in European society.
5. Mother should avoid been effected by **Toxoplasmosis** because this causes a dangerous malformation for the embryo, that's by cooking the meat very well, and don't expose to stool of cats.
6. Pregnant woman should take **Folic Acid** during the pregnancy because it reduces the malformation in the nervous tube, also she should treat all the disease such as diabetes, high blood pressure and epilepsy under medical consultation.

Figure 4.8 Split lips in human

It is possible diagnose the embryonic malformation for the embryo, before birth by using Ultra sound Scan and having blood test for the mother to research about the certain protein levels which have relationship with causing malformation, also test the embryonic cells to be certain about the chromosomes by taking a sample of the liquid which is around the embryo or from the placenta.

Diagnosing the cases of malformation is important, such as in a case of not completing maturing the lungs and helps it to do the respiration function, by giving the mother a special drug before a certain time of birth. In some advanced medical centres, they may do surgery for the embryo inside the uterus, to treat some embryonic malformation, this method need special study before the surgery because it can be dangerous for the embryo.

Multiple Birth and Twin Formation

Figure 4.9 Twins (for study)

Some Eutheria (Placenta) have structured adaptation to have pregnancy with more than one embryo in each pregnancy, this is called **multiple embryos** or **multiple births**, so many eggs release from the ovary and after its fertilization it implants to the lining of the uterus in certain destinies. In human the female gets pregnant with one embryo usually in each pregnancy, and if the female gets pregnant with more than one embryo then this called **Twins**.

Types of Twins

1-Franternal Twins

This type of twins are forms from two separate eggs which are released from the ovary at the same time, and each one fertilized by a sperm. Franternal Twins don't show similarity, and the sex can be similar (all male or all female) or can be different.

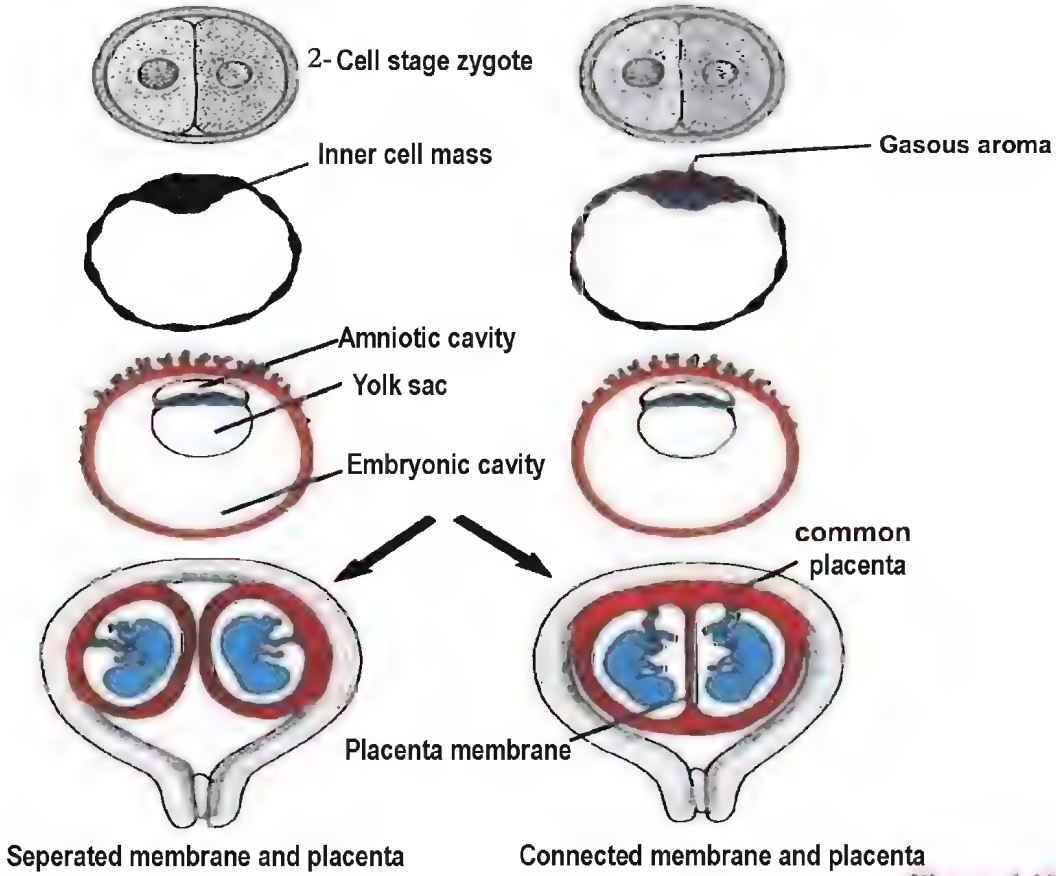


Figure 4.10 Franternal twins (for study)

2-Identical Twins

Identical twins are formed from one fertilized egg by one sperm, and this fertilized egg divides into two cells, each cell continues its growth to form a complete embryo.

Identical twins are very similar in the shape and sex (either male or female). The separation of fertilized egg can be uncompleted, this result in attached twins in the head area or chest or the back, these twins are called **Siamese twins**. The attached twins can be unequal so one of the twins is small and depend on the other one; the twins in this case are called **Parasitic Twins**.

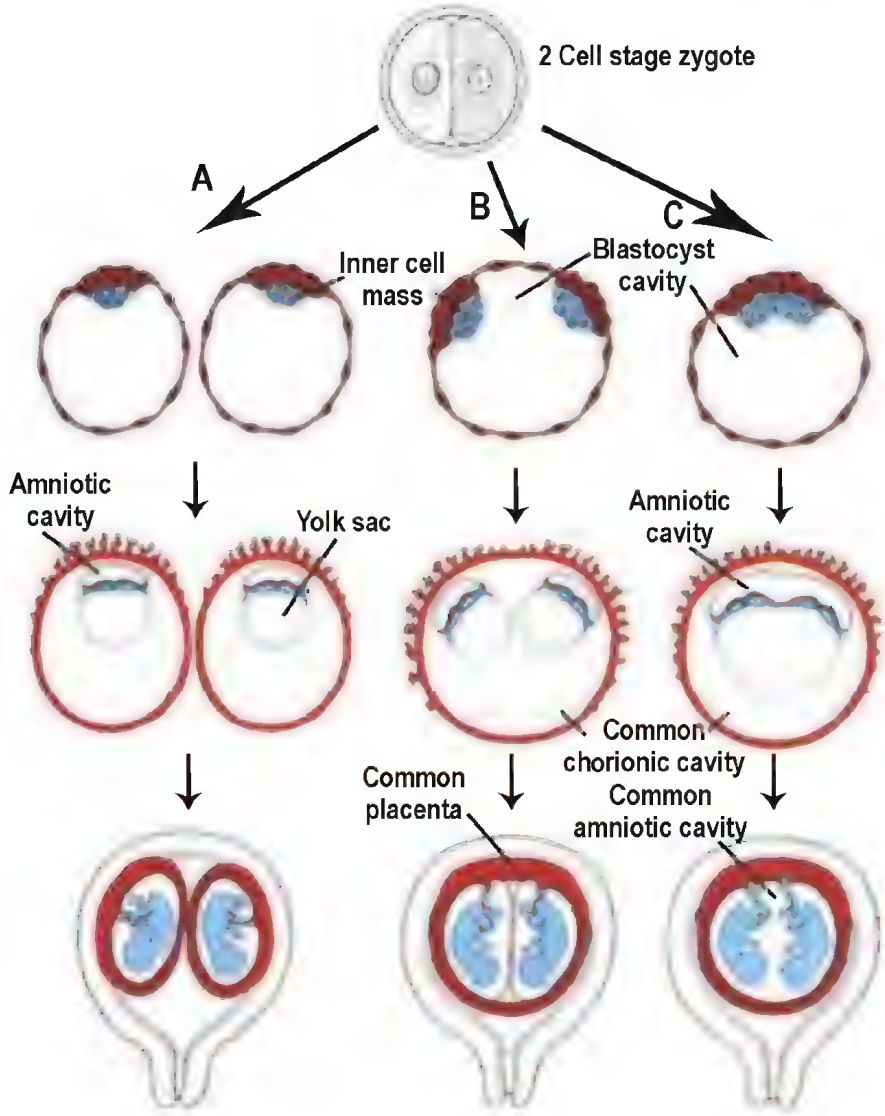


Figure 4.11 Identical twins (for study)

3-Multiple Twins

Multiple twins rarely happens in humans, some women give birth to three or four babies, each fertilized egg forms a complete embryo, this case usually happens in women who take treatment with hormones to activate the ovary or those who are subjected to the program of test tube babies.

Extension of birth periods

Mother needs at least two years between each two pregnancy and birth time that's to give a chance for the body to recover from the pregnancy and birth difficulties. Periods extension gives the child a chance of a good body and mental care, also gives the mother a chance of keeping her health. It has been found that the children who were born by time period less than two years between one and the other mostly don't achieve good body and mentally development. That can cause birth of incomplete babies, their weight is less than (**2.5 KG**) at birth, and they can be miss carried.

Stem Cells

Since discovering the **Stem Cells**, the scientists are trying to use them in the treatment of many chronic and difficult diseases, the stem cells are unspecialised cells, have got the ability for division and regeneration and produce new specialized cells which can repair and replaces the ruined body cells. Stem cells can be obtained from many resources: such as the early stages of embryonic development and the blood of **Umbilical Cord**, placenta and bone marrow.

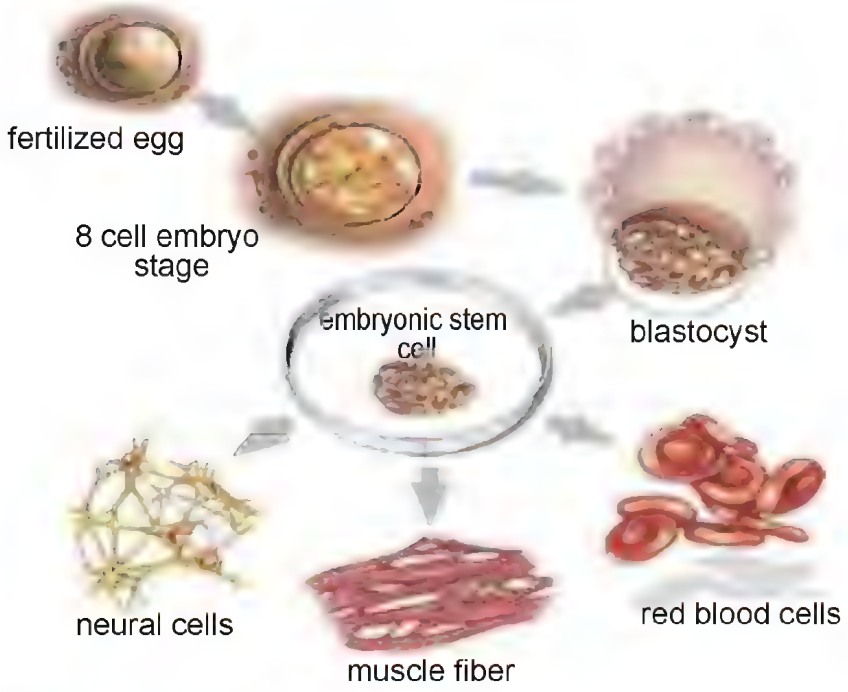


Figure 4.12 The ability of stem cells to produce different specialized cells (for study)

Types of Stem Cells:

1-Embryonic Stem Cells

This type of stem cells are basic, it has unlimited division ability and it has a high ability to specialize into diffrent types of cells, it can repair and exchange the damaged cells, when it is transplanted in the effected organs and can be obtained from an early embryonic stages after fertilization, because of that it is an important resource for many of medical achievements.

2- Adult stem cells

These cells are found with the specialized cells in the body and its function includes exchanging and replacing the harmful or dead cells in the body, but it differs from embryonic stem cells as in the following:

A. Their limited existence which makes it difficult to separate from each other.
B. Their number decreases as the age passes.
C. They can be abnormal.
D. They don't have the same ability for specializing and division as the embryonic stem cells.

3-Umbilical Cord Stem Cells

These cells can be taken from the blood of Umbilical cord, it classifies as another type of an adult stem cells because they are similar in the structure and the function, also their ability to resist freezing condition (-196C) in liquid nitrogen for many years.

The applications of stem cells

The important uses of stem cells are the following:

1- Determination the causes of untreatable diseases and congenital disorders which caused by disorder in division and specialization of the cells.
2- Used in overcome the immunity rejection in organ transplant.
3- Used in genetic engineering to understand and treat many diseases including genetic diseases.
4- Used in experiments on drugs to know their consequences.
5- Used in **Cell Therapy** for many diseases such as Alzheimer, Parkinson, joint infection and burns.

Nanotechnology is full and accurate control in molecule size (Nanometer=10^{-9} meter) to produce certain materials through control in molecule reaction. This technique has been joined with research of the Stem cells, for the purpose of understanding how to direct those cells, and controlling its purpose, and getting advantage of using that in cell therapy.

Cloning in Animals

Cloning is one of the asexual reproduction methods in animals. Cloning is economically important, because through it animals can be produce from body cells.

In **1997** Scientist **Ian Wilmot** announced that he was able to clone a sheep called Dolly from body cells which are taken from an adult sheep, this was the first time they can clone vertebrate animal.
To achieve this work Ian Wilmot and his studemts followed the following steps:

1- Cells were taken from mammary glands of an adult sheep at the age of (6) the cells were put in transplant media, the transplant media is adapted to be able to keep the nuclei of cells settle.
2- The egg was taken from another sheep, they removed the nuclei from these cells.

3- Process of joining between the donor cell (the cell of mammary gland) and the cell which the nucleus has been removed from by putting these two cells together and exposing them to an electric shock which lead to merge them and another electric shock lead to the activation of the egg to start embryonic development.

4- The product embryo was transferred to the uterus of another sheep.

5- After the pregnancy period (five months) was over the sheep **Dolly** gave birth to exactly similar sheep to the sheep which the body cell was taken from.

6- The **DNA** test showed that the nuclei of sheep's dolly cells where the product of the same donor cell's nuclei.

After that they have acheived the same results by using cows and rats.

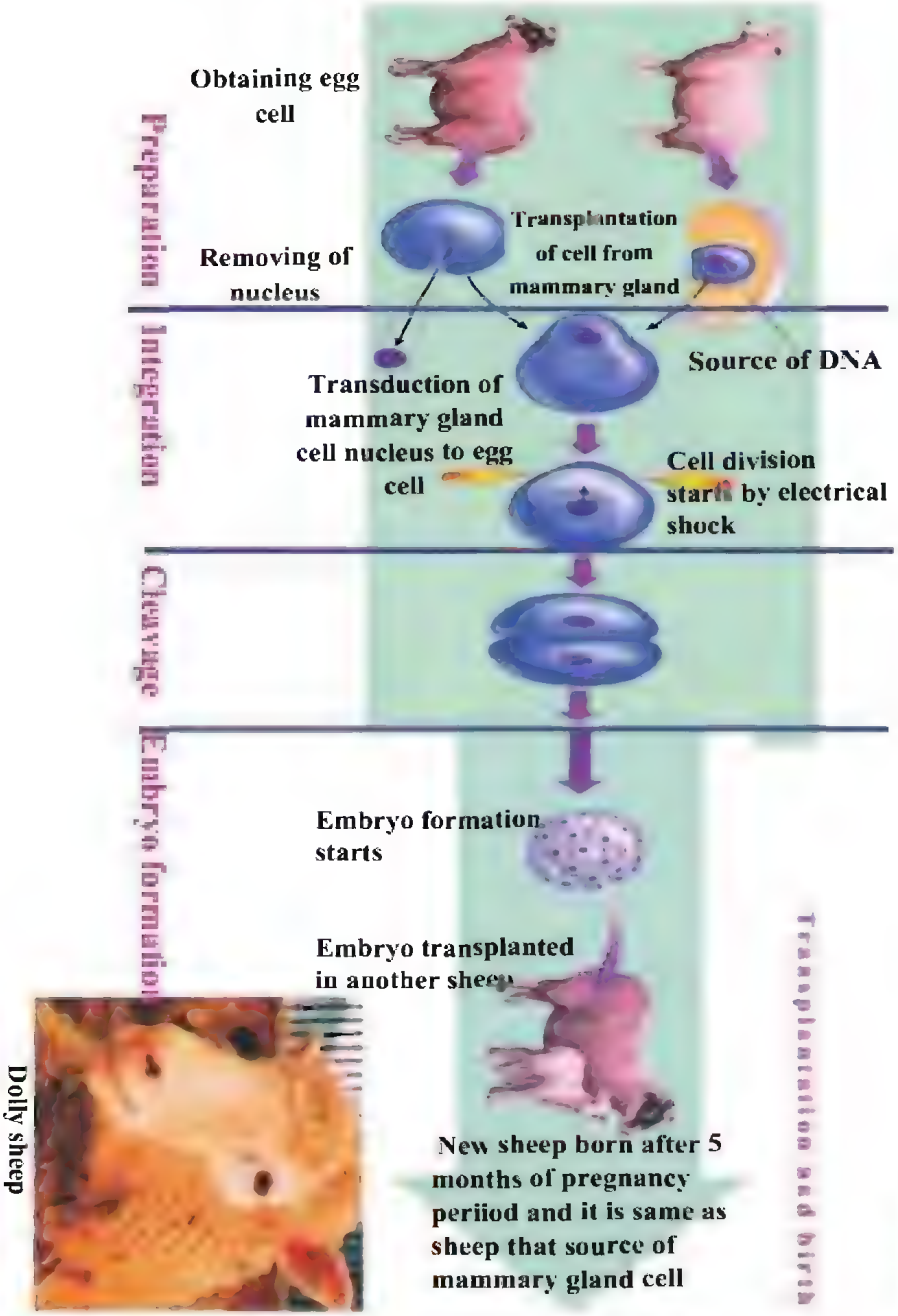


Figure 4.13 Cloning dolly sheep (for study)

Techniques to treat the Infertility

The science could solve many cases of infertility by medical treatment, most of them needs treatment by hormones or by surgery, that's by using many techniques, they are:

1-Artificial Fertilization

Artificial Fertilization represents the process of transferring the sperms after cleaning and concentrating them in the laboratory into the eggs, this fertilization is used in many cases, they are:

1- Reasons considering the ovulation or the Fallopian tubes or the lining of the uterus in female.
2- Reasons considering the male reproduction system that cause reduction in the sperms numbers, failure in fertilizing the egg. The studies show that drinking alcohol and smoking reduces the production and the activity of the sperms.
3- Hormone failure which effects producing the eggs and the sperms.
4- Exposing to the accidents or having some medicines or exposing to radiation.

Types of Artificial Fertilization

1-In vivo Fertilization

This type of fertilization takes place by injecting the semen (sperms) of the husband inside the uterus of the wife, by special tube (Catheter) and to get a good result. This operation should be done at the ovulation time for the woman, with giving her the medicine which activates the ovary.

2- In Vitro Fertilization

This kind of fertilization is regarded as the most common in the world for the cases of infertility, it means fertilizing the egg by the sperm in a test tube with injecting the hormones which activates the ovary the fertilization takes place after taking the eggs from the ovary by an ultrasound machine.
Then these eggs replaced in the special transplant media and then the active sperms added so fertilization can take place. This process takes place in a temperature which is similar to the mother's body, usually three embryos transferred (to guarantee the fertilization) they are in the first stages of cleavage to the uterus of the mother by a special tube to implant them into the lining of the uterus with giving the mother some medicines which helps to fix the embryo in the uterus.

The results of this fertilization are the most successful; because the best embryo can be chosen to be transferred to the mother also it gives a high possibility of pregnancy in one time that's through transferring more than one embryo inside the uterus.

Before starting this process there are some tests that should be done for the couple which includes blood test, the uterus test, Fallopian tubes test and sperm test. Also there are many factors which lead to failure of the fertilization by In vitro fertilization the most important one is the type of sperms and the egg and their safety. The older mother, because the older eggs have less ability to fertilize, this technique spreads in many special centres in the world including the centres in Iraq.

2-Embryo Freezing

This technique is used in In Vitro Fertilization (test tube babies) that through freezing the extra embryo after choosing the suitable embryo and transfer it to the mothers uterus. So it can be used later in the future if the couple would like to have another pregnancy, that's because the program of fertilization by test tube is economically costly, also needs health and psychological preparation. The embryo can be frozen by a liquid nitrogen (-170C) in a special scientific centres.

3-Oocyte Freezing

This techniques includes freezing the parts of the ovary which contains the immature eggs in the liquid nitrogen (-170C) the rate of success is less than in freezing the embryo, because freezing can affect the chromosomes of the egg. This technique helps the woman to keep her fertility, especially those who had been exposed to radiation or chemical treatment or some diseases.

4-Sperm Freezing

This technique includes freezing the sperms in the liquid nitrogen (-170C) the sperms (semen bank) can be kept in a small plastic tubes or a special discs to be used when needed. So gradually get it warm in room temperature, it has been found that this operation wouldn't affect sperms fertility.

This technique is used in many cases, like in some men who suffer from cancer and they need chemotherapy treatment or the disease of the testicle and they are exposed to remove it, also the men who are exposed to continouse sperms number decrease.

Review

Q.1 Write the suitable scientific term in the following:

1. .....ability of embryonic cells in the early stages of embryonic development to get the functional ability.
2. ..... ability of a certain tissue for differentiation after receiving Induction signals enables it for differentiation.
3. ..... is the science which explains the phenomenon of embryonic development according to the role of bio-chemistry by using special machine.
4. ..... are non-equal connected twins, one of them is small and depend on the other one.
5. ..... are the full controlling techniques in the molecules by the size of nanometer to produce a certain material through controlling reactions of molecules.

Q.2 Define the followings:

Growth, Embryonic development, Morphogenesis, Gastrula, Morula, Multiple Twins,
Embryonic Stem Cells, Artificial Fertilization.

Q.3 Complete these statements with suitable answers.

1. The process of growth takes place by :
.....
2. The two scientist who discovered the phenomenon of Embryonic Induction are.....and.....
3. The gastrula in the embryo of invertebrate is consist of two layers are .....and.....
4. Granular of yolk in the egg of Amphioxus distributes unequally in the cytoplasm, so it is less concentration in the side of .....and more concentration in the side of .....
5. The body of amphioxus has four main contents:
a..... b.....
c..... d.....
6. Neural Tube formation in Amphioxus is called.....the embryo through that called.....
7. There are three types of Stem Cells are:
a..... b..... c.....
8. In the year .....the scientist ..... announced that he could clone a sheep called.....

Q.4 Explain and justify the following facts.

1. At the current time the theory of Pre-formation and Epigenesis Theory can be accepted.
2. An adoption happens on the surface of zygote in Amphioxus.
3. At the end of Gastrulation in Amphioxus, the Blastopore changes into small hole.
4. The pregnant mother is advised not to take medicines without doctor's consultation.
5. Mother needs at least two years between each pregnancy and birth.
6. The success rate of freezing the egg is less than the success rate of freezing the embryo.

Q.5 Surround the letter which indicates the correct answer:

1.Who established the descriptive embryology?
a- Bonnet b-Aristotle c-Hippocrates d-De Graaf

2.The scientist Leewenhock described the sperm in the year
a- 1677 b-1678 c-1766 d-1687

3.The scientist who showed that formation of new individual requests male and female gametes is:
a- Leeuwenhoek b-Wolff c-Spallanzani d-Von Baer

4.The first scientist who conducted an experiment on the egg of frog in first cleavage stage was:
a- Spemann b-Roux c-Wolff d-Spallanzani

5.One of the embryonic development stages which differentiation of tissue takes place:
a- Cleavage b-Gastrulation c-Differentiation d-Organogenesis

Q.6 Compare between:

1. Differentiation stage and Organogenesis in the embryonic development
2. Franternal twins and identical twins.
3. Embryonic stem cells and Adult stem cells.
4. In vivo fertilization and in vitro fertilization.

Q.7 Explain the followings:

1. Von Baer law.
2. Cleavage stage of the embryonic development in Amphioxus.
3 The applications of stem cells.
4 The steps that the scientist Ian Wilmot followed in cloning.
5 The cases which the artificial fertilization is used for.
6. The changes and transforms that take place in the stage of Metamorphosis in frog's tadpole.

CHAPTER 5
GENETICS

Contents

Objectives

1- Know some genetic concepts in ancient civilizations.
2- Draw the pedigree of a family with genetic disease.
3- Define Mendel's first and second laws in genetic.
4- Compare between the first and second laws of Mendel's in genetic.
5- Identify the seven characters studied by Mendel.
6- Know that dominant and recessive traits either be pure or hybrid.
7- Explain the concept of Punnet square.
8- Compare between genotype and phenotype.
9- Explain the reason of many phenotypic traits existence.

Chapter - 5

Introduction and History

Genetics is known as branch of Biology that deals with inherited variations of an organism or a group of organisms, as well as how the expression of genes responsible for those variations.

Genetics is concerned in the followings:

1. Transmission of genetic traits from one generation to another.
2. Explain the molecular structure of the genetic material and know the changes happen in their structure and their various applications.
3. How the genetic expression occurs at the phenotypic and molecular level.

The first person who named this branch of science as Genetics was an **English** researcher called **Bateson** in **1906**. There is a brief historical overview of the most important genetic studies that helped in the progress of this science.

1. Firstly the genetic variations for the useful types were selected. The recognized characteristics were chosen which serve generations, considering everyday life requirements, especially in the agricultural field.

2. **Mendel** produced a system to control heredity qualities which was not associated with sex. He published an article in **1866** entitled Experiments in plant hybridization. Unfortunately none of the scholars of his time paid attention until after 34 years.

3. The discovery of Mendel's experiments (**1900**) has gone beyond and that time was called "**golden age**" for cell biology. It is assumed that chromosomes are carrier of genetic traits which not realized before.

4. The third quarter of the 20th century was a period to find solutions for many questions. **DNA** which described by the two scientists James Dewey Watson and Francis Crick in 1953 and molecular structure of DNA understood. This scientific researches showed the way to solve the **genetic code.**

5. Geneticists began to study about the field of bio-technology in the seventies. They were able to hybrid the **DNA** of different types in order to find very effective drugs. At the same time, they succeed in discovering the genes that cause most rare genetical diseases caused by a single gene. Therefore diagnosis method has been developed and they developed tests before appearance of symptoms. In addition new types of treatments were invented through the genetic engineering.

6. In **1986** the idea of using **DNA** in applied fields has started due to the DNA have a number of characteristics, including:

- DNA has ability to be transported from one organism to another by some transporters such as viruses and plasmids.
- It has ability to modulate the recipient cell functions.
- It has ability to replicate inside a cell naturally and also outside, through the use of **Polymerase Chain Reaction** (**PCR**).

A **plasmid** is a small DNA molecule that is physically separate from, and can replicate independently of, chromosomal DNA within a cell.

7. At the beginning of the twenty-first century, especially in year of **2003** the sequence of nitrogenous bases has been fully unveiled and it found that there were more than **3.3 billion** genes of human chromosomes, called the **genome**.

8. Genetic research currently focuses on **Genomics**, about how gene expression takes place in different organisms, whether in patients or in healthy. As well as reserces done for detection of differences that has the priority in character building and their differentiation.

Pre Mendel's genetics

Role of Mesopotamia civilization

Ancient civilization in Iraq made studies on varieties of wheat, rice, cotton and beans, as well as cattle and horses, during the period between the year **800 – 4000** BC.

These documented through the seals that were found there. For example, it was found among those documents a unique message written in cuneiform script about **1360 BC**. This has given an accurate description on how to train horses and select the best ones for the race.

Role of Nile Valley Civilization

Some applications of genetics have started with the Nile Valley Civilization in years of **5000** B.C. It was found with the Pharaohs of ancient Egypt on the types of wheat with selected quality and abundance of production.

The role of the Greek civilization

The Greek philosophers were interested in clarifying the similarity between relatives. **Hippocrates** (460 - 370 BC) referred the repetition of certain human qualities such as **Crossed eye** and **baldness** in a certain group of families.

He also noted the spread of certain diseases such as epilepsy and certain types of blindness in certain families. Greeks discovered the symptoms of some human syndromes such as (**Down's syndrome**). They were also concerned with the structures which provides the natural body immunity.

Figure 5.1 Albino human (for study)

The role of the Europeans before Mendel

The biologist scientist **Maupertuis** was one of the scientists who highlighted the importance of human genetics. He collected records of **Pedigrees** of the families that have **albinism** and analysed and predicted probability of occurrence in the future generations through the application of the theory of probability.

In the mid-nineteenth century the scientists applied cases of transmission of certain genetic traits in human, such as the eye color (Brown x Blue) and body hair color (Black x White). incats This was applied to cattle for abundance of hair and flesh.

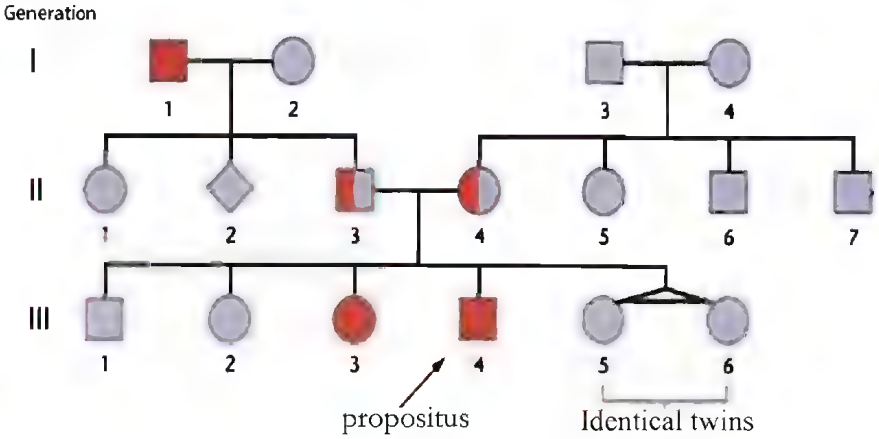


Figure 5.2 Example for pedigree. It shows how albinism passes through generations.

After mid-nineteenth century, **August Weismann** put forward a theory that **germplasm** is the genetic material transmitted from one generation to another. Based on the above facts the genetic facts are regarded as one of the familiar since ancient times to the extent that it was taken at face value for granted. The difference between individuals was complicated and no analysis or explanation applied to it at that time. Inspite of that some biologists tried to develop certain insights to explain the phenomena of the similarities and differences, but they unfortunately have been unable to devise experimental method based on a scientific basis until the coming of the Austrian researcher **Mendel**. Mendel made major assumptions about the transmission of genetic traits through results of experiments on plant Pisum sativum (Pea Plant).

Germplasm is the genetic material transmitted from one generation to another.

Mendelian genetics

Gregor Johan Mendel was the first one who succeeded in the Discovery of the basic principles of genetics. Mendel was born in Austria (**1822**). Mendel began to hold experiments on **Pisum sativum** in 1856 and has multiple experiments lasted approximately eight years. Later Mendel presented his research findings to journal of **Natural History in 1865**. His research were published after one year from the date above, but unfortunately the results of his research remained under wraps for a period of 34 years from the date of publishing as the scholars were preoccupied with the theory of Darwin (**1809 – 1882**) in organic evolution.

In the early twentieth century Mendel hypotheses in genetics were represented as a result of research done by three different research scientists who agreed with Mendel's principles in genetics. These three scientists, Dutchman '**De Varies**', the German '**Correns**' and the Austrian '**Tschermak**', who were interested in studying function and behaviour of chromosomes.

Figure 5.3 Gregor Johan Mendel

Some properties of living organisms used in genetics experiments

It is well known that studies in genetics depend on the design of experiments and analysis of results. This was for the purpose of extracting certain hypothesis about how to move different qualities. Here are some considerations that need to be taken into account when using a particular object for the purpose of conducting genetic studies:

1. Short life cycle.
2. High number of offspring
3. Having the possibility to get variations and genetic mutations when organisms are exposed to unsuitable environmental conditions such as radiation and chemicals.
4. Ability to control fertilization or mating of the organism.
5. Easy to breed and maintenance.
6. Ability to produce new structures as a result of sexual reproduction or delivery (**Transduction**) by **viruses**.

Many research conducted on bacteria, fungi and some plants like garden pea, yellow corn, barley, wheat, squash, tomato and snapdragon.
Many traits in animals as drosophila, mice, chicken, guinea pig and cattle, as well as in humans.

Common Name for plant name	Number of chromosomes somatic cells	Common name for animal type	Name of chromosomes in somatic cells
Pea	14	Mosquito	6
Corn	20	fruit fly	8
Bean	22	Bee	32 / 16*
Rice	24	Cat	38
Grain	28	house mouse	40
Sunflower	34	Human	46

Table 5-1 shows the number of chromosomes in the somatic cells for different kind of living things.

*** Male bee (drone) has half number of chromosomes.**

Application of genetical Models in Mendel Experiments

The success of Mendel in his experiments despite of failure of other scientists may be caused by;

1. Chosen best model in design and analysis of genetic experiments. It is Pisum sativum which has genetic variation, ability to grow easily and susceptibility to hybridization artificially.

2. Mendel limited his research on one pair of traits or less in each experiment.
3. Keeping accurate records and relied upon in the statistical analysis of his experiences.

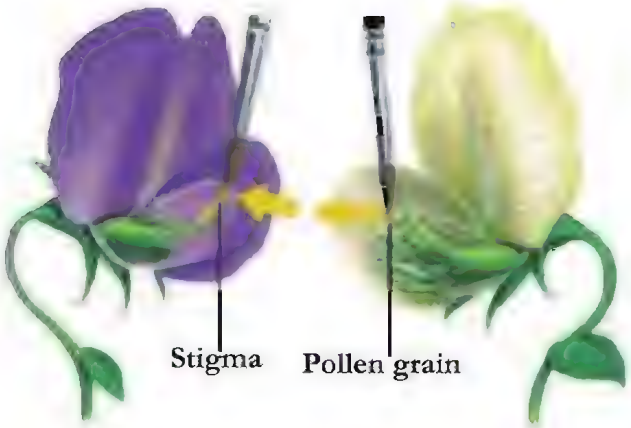


Figure 5.4 Mendel used artificial cross pollination in pea plants for his experiments (for study)

Character	Dominant Trait	x	Recessive Trait	F_2 Generation Dominant:Recessive	Ratio
Flower color	Purple	x	White	705:224	3.15:1
Flower position	Axial	x	Terminal	651:207	3.14:1
Seed color	Yellow	x	Green	6,022:2,001	3.01:1
Seed shape	Round	x	Wrinkled	5,474:1,850	2.96:1
Pod shape	Inflated	x	Constricted	882:299	2.95:1
Pod color	Green	x	Yellow	428:152	2.82:1
Stem length	Tall	x	Dwarf	787:277	2.84:1

Figure 5.5 Seven pairs of contrast traits which Mendel used in his experiments (for study)

Some genetic terminologies and symbols

For the purpose of understanding mono-hybrid cross and the theories that have been derived from it we have to know number of new terms used in this field, namely:

1. Allele

Different form of mutation of a gene. One of the different forms of a gene that can exist at a single locus.

2. Genes

Is a sequence of DNA that has a specific function, for example, turning the genetic code to a protein or controlling the expression of character and can prove itself through contrast alleles.

3. Gene Expression

It is the process of using DNA information by cells in the manufacturing of a particular protein.

4. Genotype (G)

It reflects the composition or structure of the genetic of individual. It expresses the genetic codes together in a particular individual.

5. Phenotype or phenotypic category (P):

It refers to the properties or observed signs of the organism which is genetically controlled. For example, stem length and stem shortness in Pisum sativum plant referred to as expressions of natural information. These are available in the genetic factors. By following the principles of dominant and recessive traits we can tell about phenotype for the individual from the genotype. For example **TT** and **Tt** refer to the long stem and **tt** refers to the short leg. When the individual carries genetic factors such as symmetric **TT** or **tt** it is said that the individuals are homogeneous or pure (**Homozygous**). When the individual carries a genetic model which are not symmetric factors such as **Tt**, it is said that the individual is heterogeneous or hybrid (**Heterozygous**) (figure 5.6).

The diagram gives an example of crossing between a homozygous, dominant trait and a recessive trait as well as modern terminology used.

In connection with the genetic factor codes, usually different ways are used. We now mention the symbol for one of Mendelian traits, say the stem length in Pisum sativum. This is given the symbol capital letter (**T**) in order to refer to the tall stem. The small letter **t** refers to the short stem trait, which recessive trait. In this case special symbol is derived from the dominant trait.

To point out a short stem trait, the code is derived from the dominant trait.

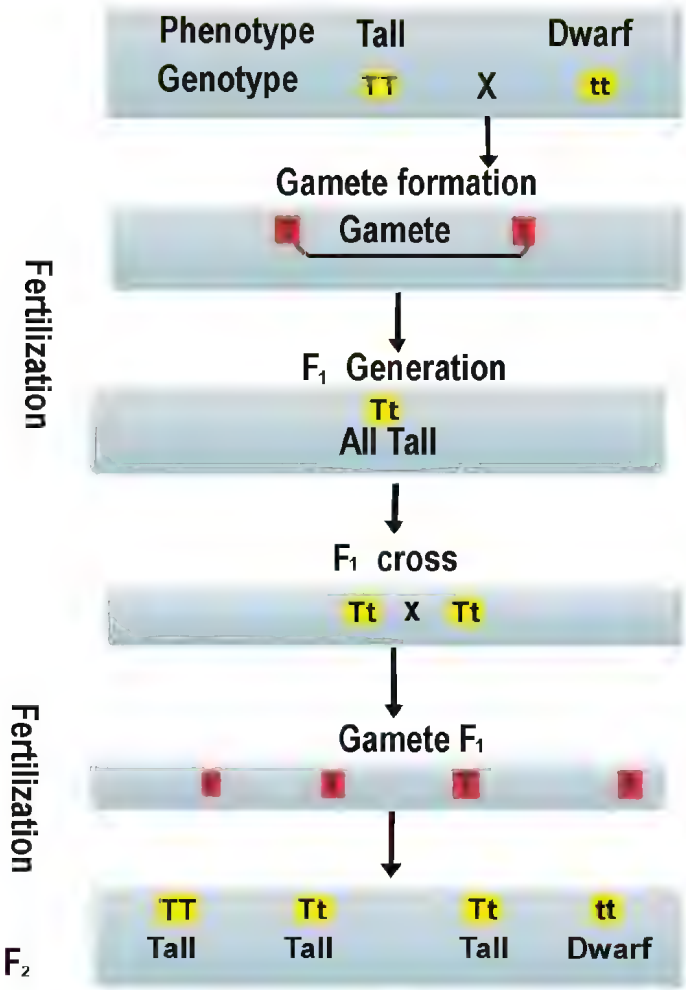


Figure 5.6 Showing the use of some genetical terms and symbols by an example

Table 5-2 Some genetic codes used in crossing and also in solving the genetic issues:

Symbol	The meaning of the symbol
F	The first generation is taken from the word Filial Latin it means offspring, and so on For the second generation F_2 ... etc.
G	Refers to the parent gametes , and G_1 for first generation gametes
P	refers to native parents and thus for the P_1 ... etc
X	Mark of mating, crossing or pollination or hybridization.
♂	Latino code refers to the father or male
♀	Latino code refers to the mother or female

Monohybrid Cross

This a genetic hybridization between two individuals and includes a pair of opposing traits, such as **aa X AA**. Thus it reveals how transmission versions of these qualities through the generations take place.

Example:
For Monohybrid Cross Mendel

The trait for stem length in Pisum sativum plant is an example of mono-hybrid cross. When hybridization between Pisum sativum long stem pure with similar but short stem happens, all members of the first generation (F_1) were long stemmed. When conducting self fertilization among the members of the first generation, Mendel noted that **787** of **1064** of second-generation plants (F_2) were long, while **277** of **1064** were short. These figures represent the approximate ratio **2. 84 : 1**. This is about **3:1**. So the recessive trait that did not appear in generation (F_1) but appear in the second generation (F_2) by**25%**.

Evidenced by the results of Mendel show that the results do not depend on the sex. This means that the traits are located on the somatic and not sexual chromosomes.

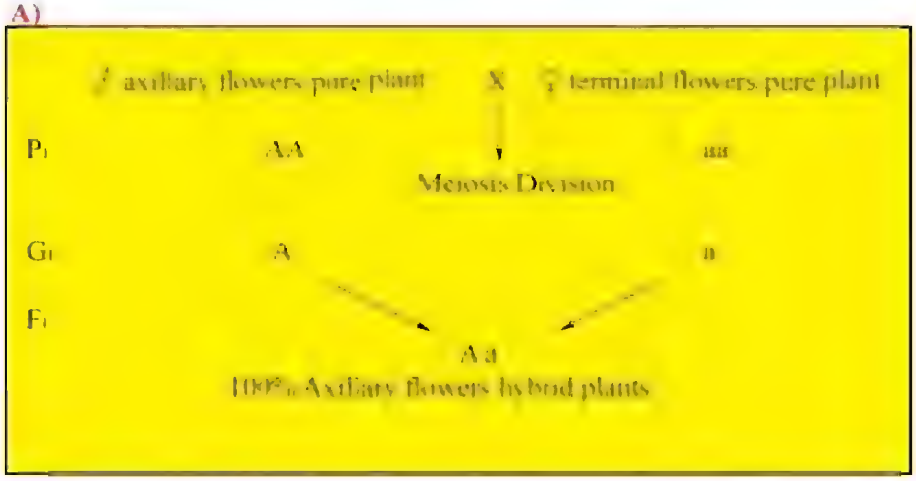
Usually **reciprocal cross** is used for the purpose of making sure that certain trait has the gene located on either the somatic chromosome or sexual chromosomes, or located in cytoplasmic organelles such as mitochondria.

Definition of Reciprocal cross:

Crossing gets between two individuals, one carrying a dominant pure trait and the other carries the recessive pure trait or vice versa.
If the results in both cases are similar then the gene for that falls on the somatic chromosome. If the results were different at the opposite type, it means that the trait gene located on sex chromosome or in the cytoplasm of organelles. This is shown in the following example on Pisum sativum.

Example of reciprocal cross in Pisum Sativum:

A)



B)

♂ terminal flowers pure plant X ♀ Axillary flowers pure plant

P1 aa AA

Meiosis Division

G1 a A

F1 Aa

100% axillary flowers hybrid plants

Mendel concluded that traits is located on the somatic chromosomes. In order to clarify these results Mendel assumed the existence of a pair of genetic factors for each trait. These are the factors that control transmission capacity from one generation to another. This confirms the success of Mendel in his experiments.

Mendel's Postulates

Mendel agreed with results, which he obtained in mono hybridization in order to derive three hypotheses or principles in genetics, as follows:

1. Unit Factors in Pairs: This means that every trait is carried by an individual is controlled by a pair of factors. Usually the **diploid** organism contains one of three genotypes which determine the trait and they are (**AA or Aa or aa**).

2. The dominant and recessive traits: The dominant and recessive are; when there are two factors which are not similar (**Tt**) which are in charge of one trait in any individual, one of these factors (**T**) is dominant over the recessive trait (**t**). However the recessive factor is responsible of showing the recessive trait when it comes as a pair (**tt**).

3. Segregation during the formation of Gametes formation

The two factors which are not similar (**Tt**) split randomly. So each gamete will receive one of these factors in equal propability

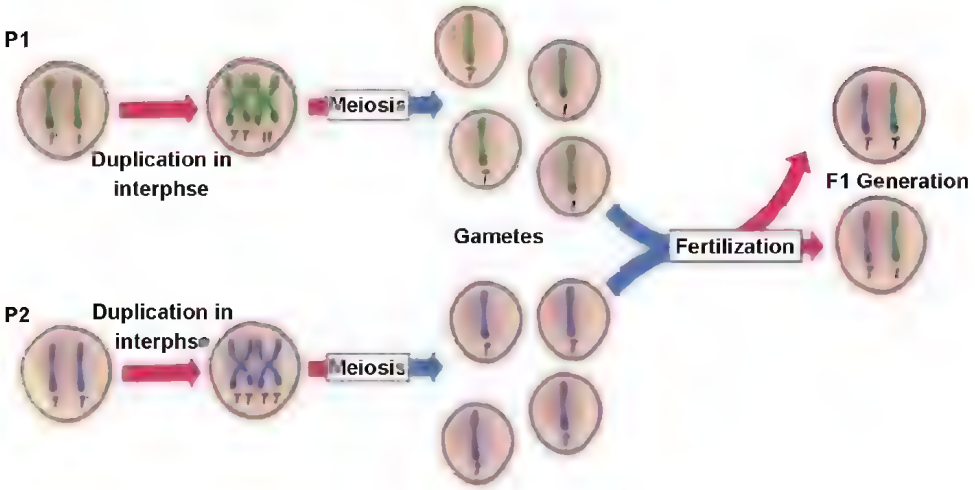


Figure 5.7 Law of segragation (first law of mendel)

If the individual has a pair of similar factors (tt) or (TT) this lead to the fact that all the gametes will receive one factor. After fertilization, the first generation individuals (F_1) receive one factor from each, so the resulting individuals have a pair of factors. During the self fertilization in the first generation (F_1), each gamete randomly receives either the dominant factor or the recessive factor. After fertilization there will be four units for the formation of the second generation F_2 at the ratio: Dominant 3: Recessive 1. According to this hypothesis Mendel set his first law, which is called "**Law of Segregation**", which states that:

"The paired genetic factors in an individual split from each other when the gametes are formed. After it formed in pairs again during fertilization when the genetic individuals are created".

The Mendel's fourth postulate, which is called free distribution, considers that later as part of Mendel's second Law.

Punnet Square

The genotypes and phenotypes produced by recombined gametes during fertilization could be demonstrated visible and easily through the punnet square.

Punnet square:

Geometrical shape like chessboard which the male gametes are placed in its left and vertically above the gametes. The female gametes are placed above and horizontally towards the male gametes. In this case you can see all possibilities of the units male and female as well as knowledge Phenotypic and genotypic models and their respective ratios.

Note each of genotypic ratio (1:2:1) and phenotypic ratio 1:3 for the second members of second hybridization generation.(Figure 5.8)

Test Cross

The aim of this crossing is to identify the genotype of the individual which holds dominant unknown purity. It crossed with another recessive individual for that trait. If all the members were carrying the dominant trait, then this member must be pure in that trait. If either **50%** of the members were dominant and **50%** recessive, that means that the individual hybrid in trait.

This can be illustrated as follows:

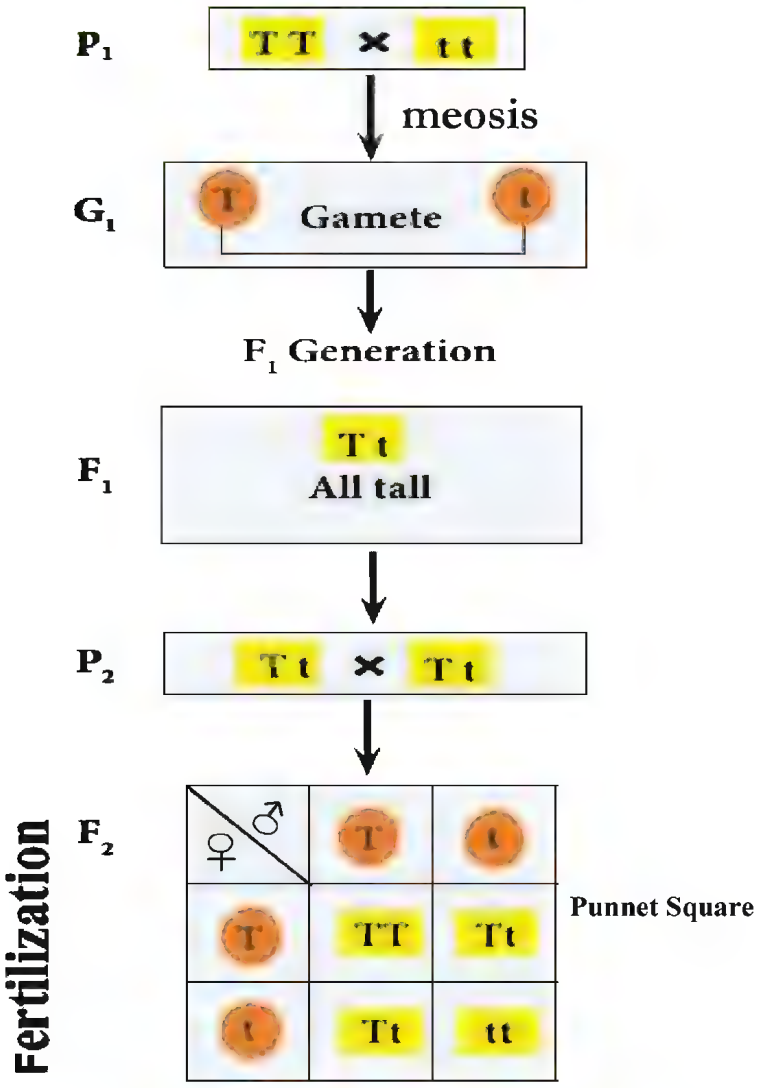


Figure 5.8 Punnet square is used to identify second filial generation(F2). F1 generation used in self pollination

The first Possibility

When the individual is pure and dominant for the Pisum sativum:

P1 ♂ long stem plant TT × ♀ short stem pure plant tt

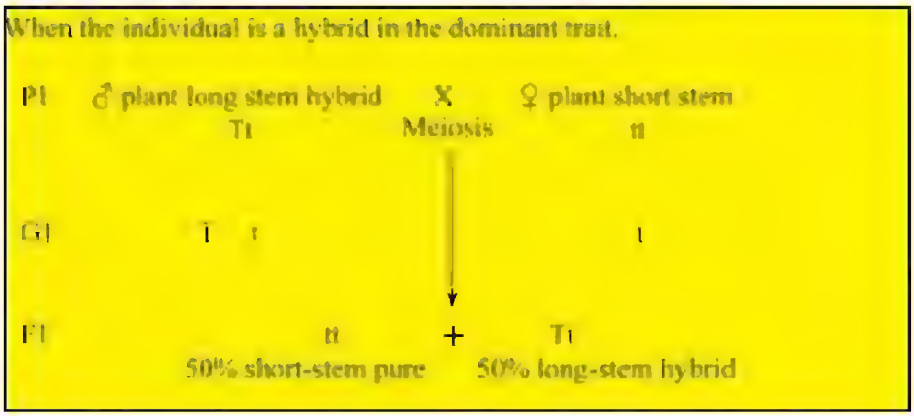
Meiosis

G1 T t

F1 Tt

100% long-stem hybrid plants

The Second Possibility:

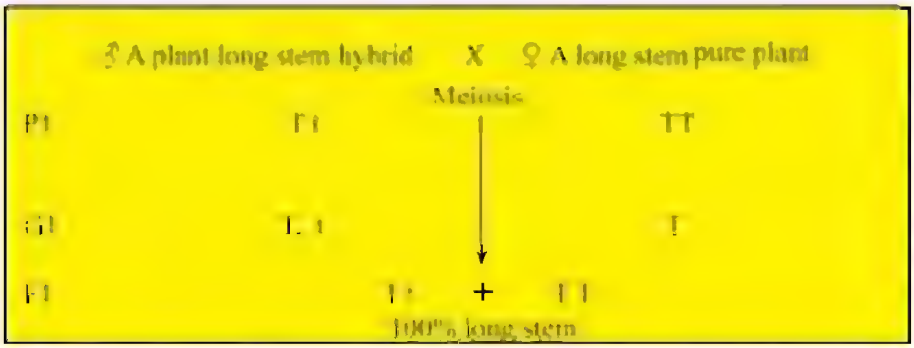


Optional crossing is regarded as part of reciprocal cross.

Back Cross

It is a cross between hybrid members of the first generation with a parent or with an individual similar to one of them.

The output crossing with pure male dominant trait can be seen in this example;



Dihybrid Cross and Free Distribution Mendel's Law

Dihybrid cross is a hybridization which includes a couple of contrast traits **ggww × GGWW.** For example, if the Pisum sativum of pure round yellow seeds conjugated with green wrinkled seeds, then all members **F1** will be round and yellow. This is because the yellow colour is dominant over the green and round seed is also dominant over the wrinkled seeds.
When allowing members of **F1** (hybrid traits) **GgWw**, for self-fertilization we find that the seeds of self-members **F2** appear in accordance with the approximate ratio **9/16** round yellow and **3/16** wrinkled yellow and **3/16** green round and **1/16** green wrinkled.

The **Law of independent assortment** and also known as Mendel second law has been developed by Mendel and enhance the fourth hypothesis which is also called as **free distribution**.

The **Law of independent assortment** states that:

"The isolated pairs of genetic factors are distributed independently from each other during gametogenesis".

This law requires that any pair of isolated genetic factors is independent from all other pairs of genetic factors. As we know each gamete receives one allele from each pair of genetic factor. Any of the factors or the recipient **alleles,** one pair does not affect any other pair. So they following this procedure. The possible gametes units are constructed made up of all by the equal repetition, the figure below clarifies the free distribution throughout the formation of the second generation members, the process of gametes by the second generation plants.

In each case of fertilization between members of the first generation (**F1 x F1**), each egg will have the same probability to receive one of the four units from each parent. In the case of the production of a large number of members of the descendent, we will get the ratio **9/16** round yellow, **3/16** yellow wrinkled and **3/16** green round and **1/16** green wrinkled seeds. This ratio is ideal because it is based on the events of probabilities of events including segregation, free distribution and random fertilization.

Deviation from these ratios can take a place (which is subject of strictly coincidence) especially in the recessive small numbers of traits so the results are rarely identical with the ideal ratio.

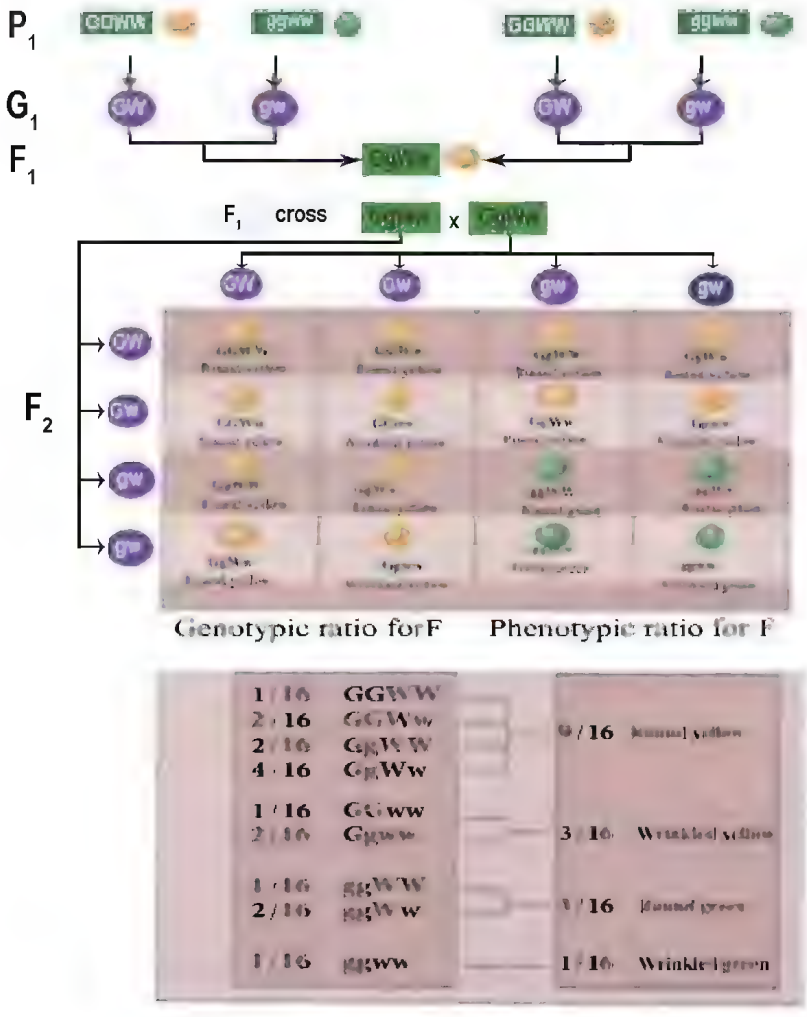


Figure 5.9 Dihybrid cross in Pisum sativum (forstudy)

Selective Crossing for two traits:

It is possible to apply optional crossing on individuals carrying a couple of opposite dominant traits with unknown genetic type (unknownpurity).As example phenotype of a plant with yellow seeds rounded dominant can produced by genotype (**GGWW, GGWw, GgWW** or **GgWw**).

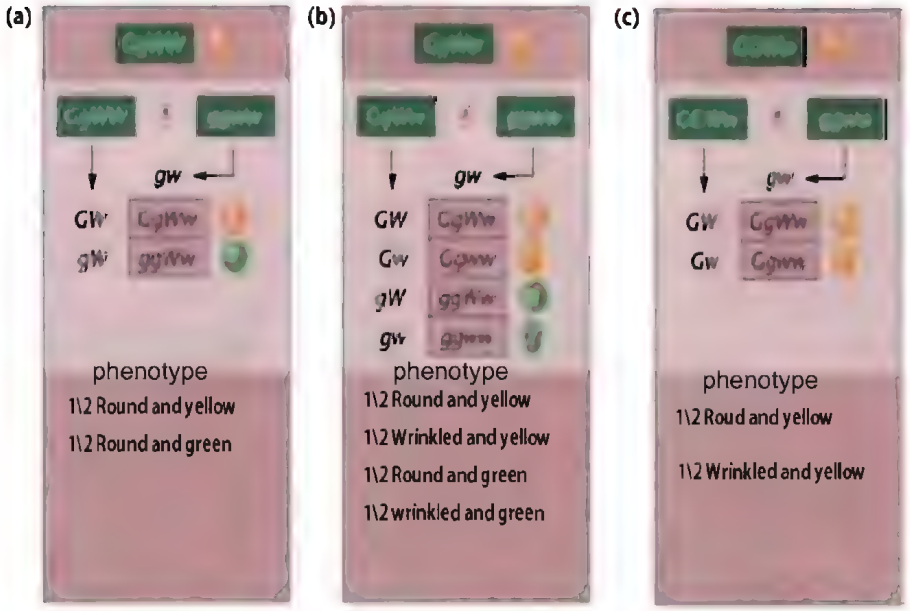


Figure 5.10 Result of hybridization between three similar organisms in phenotype (for study)

In the case hybridization of a plant with round seeds with a pure plant, green wrinkled seeds, ggww (recessive) the analysis of genetically phenotype ratio is explained in figure below.

Interpretation of the results of Mendel in the light of the knowledge of the functions of chromosomes and genes:

Chromosome: This is the installation of composite linear shape of the **DNA** molecule, **Ribonucleic acid (RNA)** and protein, which contains the coded genetic information sequence and can be viewed through the process of cell division. The gene is a part of **DNA** chromosome that controls at least in specific genetic trait.

Since chromosomes present to be matched in pairs, it is also the genes found in the image of pairs, as **Aa** for a certain trait and **Bb** for another trait and whether the individual is a hybrid of these two traits. This, of course supports the first hypothesis of Mendel.

The relationship between the behaviour of chromosomes and genes also through meiosis, each gamete receives one chromosome from and one of each pair of identical chromosomes. So when those gametes unite during the process of fertilization, the new generation receive one gene for a particular trait of the father and the other from the mother.

The free distribution of the chromosomes over the gametes during the meiosis supports the law of Free distribution of Mendel. This is because the genes being unattached. (Will not be on the same chromosome), will also be distributed independently.

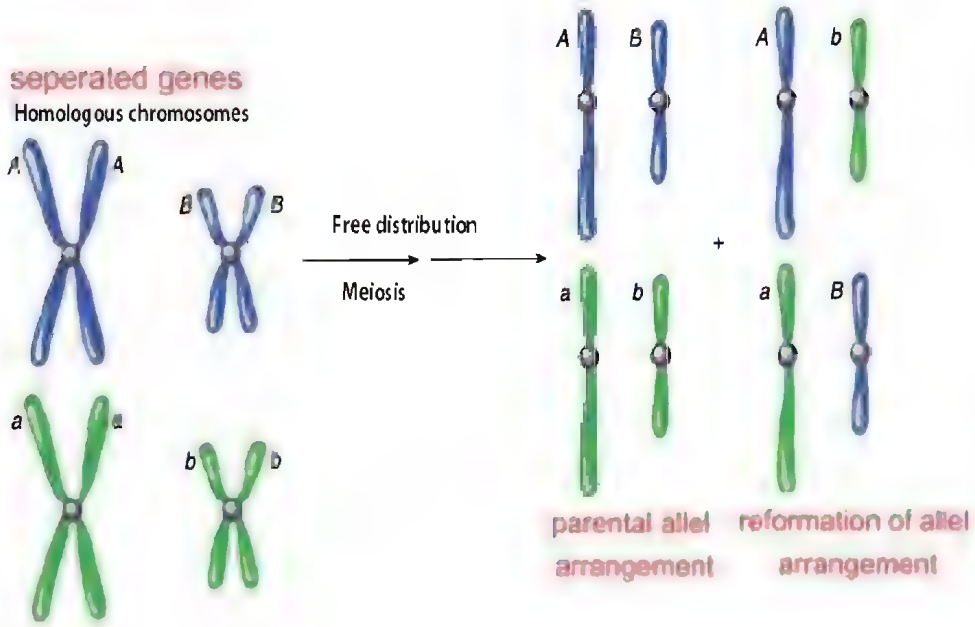


Figure 5.11 Free distribution of alleles through gamete formation (for study)

Example 1

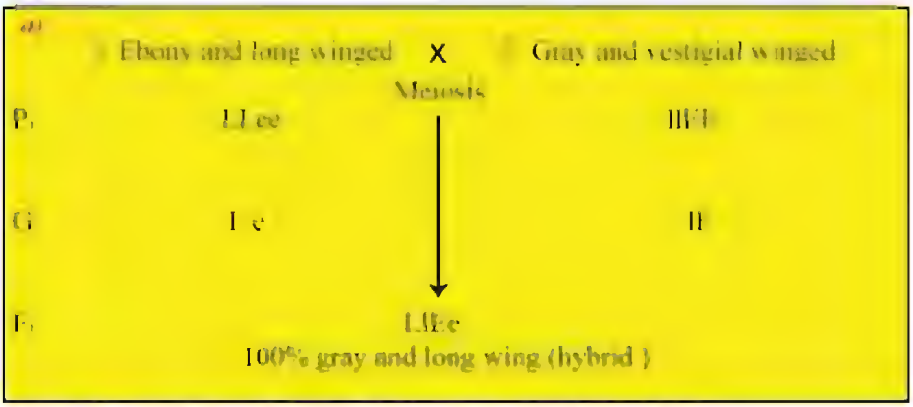
Application on Mendel's Second Law

A Drosophila melanogaster of ebony colour with long wing crossed with a gray and vestigial winged The first generation (F_1) were gray and long wing, knowing that genetic factors for these traits are located on two different chromosomes.

a. What is the genetic type for the parents and the members of the first and second-generation?
b. What is the phenotypic ratio for the F_2 members?
c. What are the genetic ratios for F_2 ?
d. Show the type and the number of units which is possible, between the gametes? Clarify that on the punnet square.

Conclusion and solution:

Since all members of the first generation were long wing and gray, then the long wing (**L**) is dominant over the vestigial winged (**l**), and the gray colour (**E**) is dominant over the ebony colour (**e**) as well as the fly with long wing and gray male must have each of these pure traits. Accordingly genotypes codes for the parents and members of the first-and second-generation will be as follows:



After being pollinated for F1 the members will be as follows:

♀ Long and gray hybrid LIEe	X	♂ Gray long wing hybrid LIEe		
P2				
G	LE	Le	lE	le
LE	LLEE	LLEe	LlEE	LlEe
Le	LLEe	LLee	LlEe	Llee
lE	LlEE	LlEe	llEE	llEe
le	LlEe	Llee	llEe	llee

When genotypes are combined in the Punnet square and that share a certain phenotypic, we get the following ratios:

a) Phenotype ratio	9 Gray Long	3 Gray Long	3 Gray Vestigial	1 ebony Vestigial
b) Genotype ratio	1 LLEE	1 LLEe	1 LlEE	1ee
	2 LlEe	2 Llee	2 llEe	
	2 LlEe			
	4 LlEe			

d) Genotype Ratio 1:2:1:2:1:4:2:2:1
e) Number of possible associations (units) between gametes = 16.

Possibilities in Mendel's genetic experiments

Probability: is the likelihood of the occurrence of a specific event by an estimation or calculations. It can be expressed as the number of decimal, percentage or number of fractional and determined by the following equation:

$$\text{Probability} = \frac{\text{Number of repetitions for an event}}{\text{Number of events}}$$

The rates of phenotypic models and genotypes in generation F2 representing potential or expected rates to those models. However, the proportion of those models that are actually obtained from mating may be different from the ideal ratios. This can be explained in Mendel's experiments on seed colour trait, as in Figure 5.5.

The number of the dominant yellow seeds was **6022** seeds, while the number of green recessive seeds was **2001** seeds. So the total number of seeds was **8023**. Using probabilistic equation can determine the true proportion of the yellow in this kind of hybridization as follows:

6022 / 8023 = 0.7506

But the real ratio for the green seeds is:

2001 / 8023 = 0.2494

To express this percentage ratio of the expected probability of the yellow seeds is **75%**. This can be expressed as a fractional of **3/4.** While the ratio of the expected probability of green seeds is **25%**. This can be expressed as a fraction **1/4**. These numbers can be expressed as ratios **1: 3** represent the same probability that number represents the fraction **1/4** and **3/4** respectively, i.e. there are three out of four opportunities. This means that every time two hybrid parents produce a new member the probability of carrying the dominant trait is **3/4.** So the probability of carrying recessive trait is **1/4**. Referring to the actual ratios obtained in this example.

Usually we find a difference between the actual ratios obtained in the field and the expected ratios. This is due to the experiment, such as its dependent on the lack of equal opportunities of gametes at the pollination process as well as the lack of equal opportunities for individual factor, hybrid (**Gg**) from segregation equality over the gametes.

When we are dealing with two traits or more and which are inherited independently of each other, we can predict all potential duplicates of phenotypic types in the second generation. This is done through the application of act of the product of probabilities. This indicates that when there are two separate events spontaneously, then the obtained probabilities of the occurrences of its members.

Post-Mendel genetics

After the discovery of Mendel's experiments in 1900, there was expansion in the study of many traits in different kinds of organisms for the purpose of applicability of Mendel's laws on the genetics of those traits and whether there are new discoveries.

It has actually found that the genetic information which has seen some traits do not actually agree with Mendel's expected ratios. So some assumptions were given in order to clarify these changes.

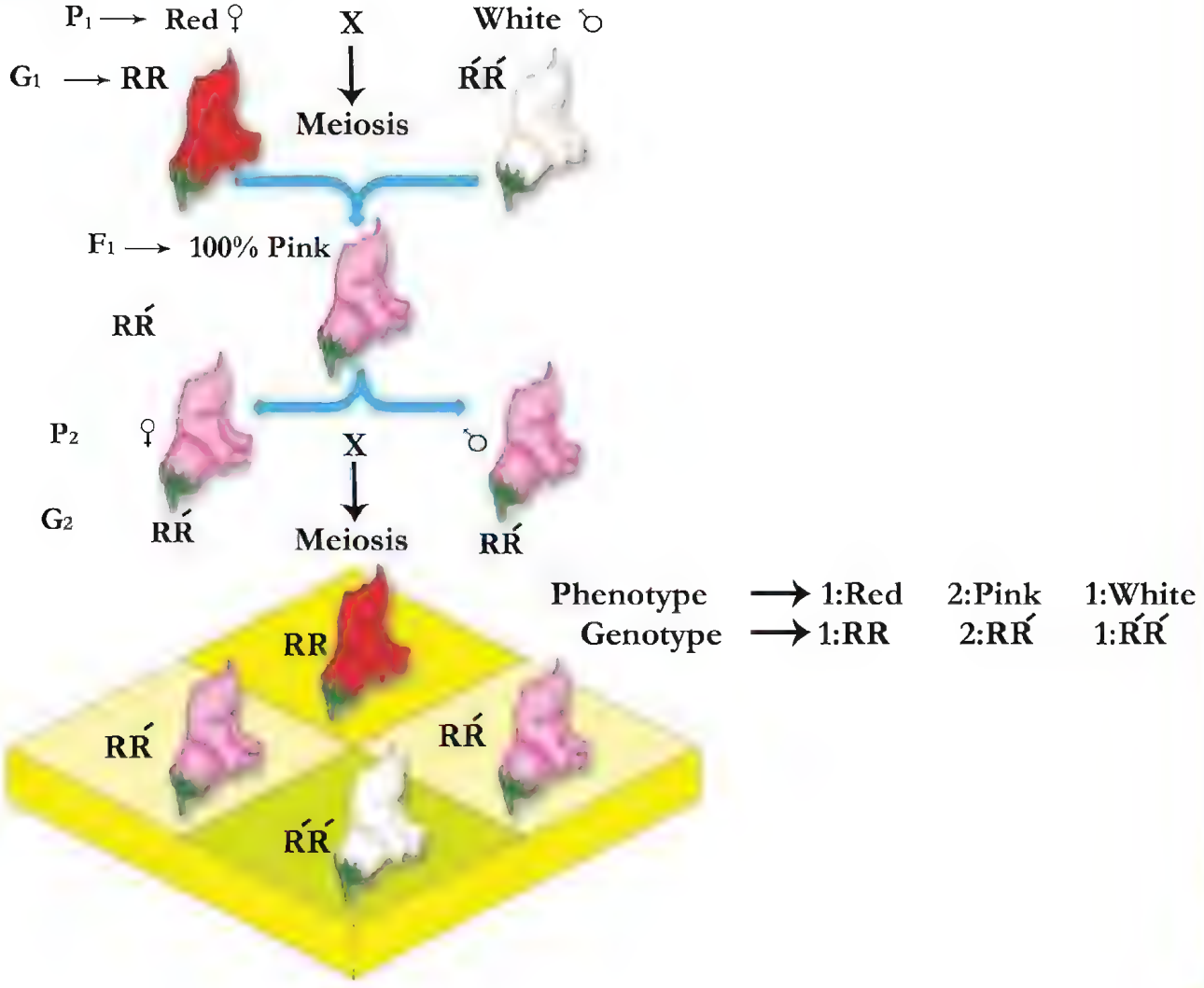
Bearing in mind phenotype for some traits are changeable by different methods, according to its genetic factors and the environments. Below are some examples for such kind of traits. They are called deviations in Mendelian rules in some references.

Properties that Deviate Mendelian ratio 3:1

a. Incomplete dominance

Phenotype of the hybrid individual is different than the parents. This takes a compromise between the two types. This is the average between the two phenotypes for the two pure opposite traits as a result of mixed cross for these two traits. This situation is different from the case of full purity of the traits studied by Mendel.

An example of what happens when the "Snapdragon" plant of red flowers R^1R^1 is pollinated with a white flower R^2R^2 plant, the first generation is pink flowers R^1R^2. In a self-pollination a member of the first generation F_1, the second generation plants would be in the ratio: R^1R^1 1: R^1R^2 2: R^2R^2 1, white, pink and red flowers respectively. This is similar to the proportion of genetic ratio as described below.



b. Codominance

This is the case in which expression of two alleles seen together in the phenotype of the hybrid individual. Neither one of the traits is dominant or recessive.

Example (1) Blood System AB, B, A

All blood groups **AB, B, A** in humans are determined by two factors I^A and I^B and these **antigens** which are available within membrane of the red blood cells. The genotype of an individual belongs to blood group **AB** is $I^A I^B$. So none of the alleles I^A, I^B would be dominant over the other. The blood cell **AB** carry **A** and **B** on its surface. When the parents carry both genetic types $I^A I^B$ get married, it would be possible to get children with phenotype and genotype in the ratio:

$I^B I^B$: 1 (B) $\quad$ $I^A I^B$: 2 (AB) $\quad$ $I^A I^A$:1 (A)

Example (2) Blood System MN in humans

An individual with a blood **M M** has antigen **M**. While another individual with group **NN** has antigen **N**. The individual with a blood **MN** possesses both the antigens **M** and **N** in the membrane of red blood cells. So at parents' marriage with the installation of a genetic $L^M L^N$. It would be possible to get children with phenotype ratio as following:

$L^N L^N$:¼ $\quad$ $L^M L^N$:½ $\quad$ $L^M L^M$:¼

The sign L is used by the scientist "**Landsteiner**" who discovered the antigens for these groups. There are two kinds of molecules "**Glycoprotein**"

Example (3) Hair colour in some breeds of cattle with short horns

There are two alleles controlling the hair colour. One is responsible for the appearance of red colour C^R and the other is responsible for the emergence of white C^W, where **C** stands for any colour and **R** for Red colour and **W** for the white. When two members are crossed, one red and one white hair, all the members of the first generation will result in "**dust**" colour, i.e. whitish red. Careful examination found that this colour is a mixture of hair some red, others white.

When a mating between members of the first generation takes place, the following phenotypic and genetic type ratios were obtained in the second generation:

White $C^W C^W$: 1 $\quad$ Dust color $C^R C^W$: 2 $\quad$ Red $C^R C^R$:1

c. Lethal alleles

These alleles will cause the affected member to suffer if the member carries it. This expression leads to death of an individual which inherit a pure dominant in some cases or recessive in other cases.

Example (4) Sickle – cell Anaemia

This genetic disease is caused by recessive mutant allele **Hbs** affects the quality of hemoglobin Hb. It becomes some kind of abnormal type (**Hemoglobin S**). It also affects the shape of red blood cells they become scythe shape instead of the normal disc shape.

It is clear that this deadly allele becomes a multi-effective (**Pleiotropic**).
The table showing the genotype and phenotype of the offspring resulting from mating between parents both for scythe anaemia.

Figure 5.12
A) Red blood cells infected by sickle cell anemia
B) Normal cells(not infected) (for study)

Genotype	Hb^AHb^A	Hb^AHb^S	Hb^SHb^S
Phenotype	Normal	Gene carries allele	Dies after adolescence

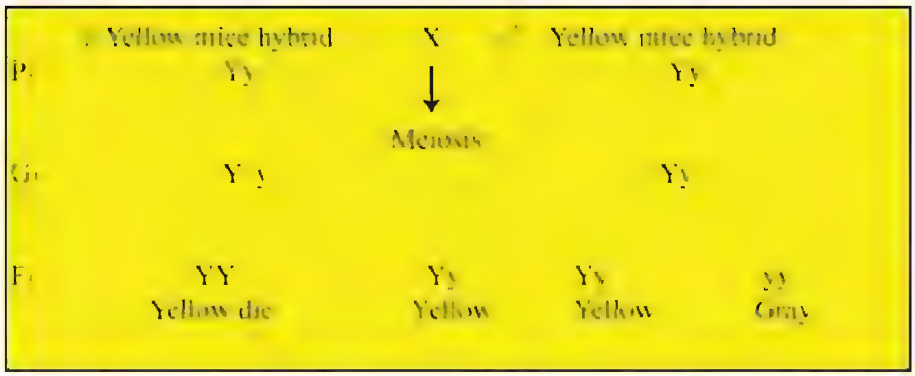
Example (2) Dominant allele for creeper chicken:

This type of chicken appears if they are having allele (**C**) together with normal allele (**c**). The chicken cannot walk normally because of the short and twisting legs. Individuals pure in this gene (**CC**) usually die. Below is an example of mating parents of creeping chicken.

	♀ Creepy chickens	x	♂ Creepy Rooster
P1	Cc	Meiosis	Cc
gal	C c		C c
F1	CC Dead	C c + C c Creeper	cc Normal (OK)

Example (3) Dominant allele for yellow mice

These are similar to the previous case. When yellow hybrid mice are mated with each other the result is, quarter of the yellow embryos will die. That is pure in the deadly allele **YY** which leads to phenotypic modulation ratio **3: 1** to **2/3** yellow hybrid: **1/3** gray. So the yellow mice are always hybrid and any carrier of the gene is not affected by it. The killing gene is important in designing some genetic tests. The following diagram shows mating of two hybrid members for this kind of killing allele.



Penetrance and Expressivity

Cystic fibrosis (CF), also known as mucoviscidosis, is an autosomal recessive genetic disorder that affects most critically the lungs, and also the pancreas, liver, and intestine.

Penetrance Gene: This is the probability of an individual inherits allele and posses phenotypic trait which is related to allele. For example recessive allele that causes **cystic fibrosis** with complete penetrance of **100%** of pure individuals (**cc**) have the disease. As well as the dominant allele to acquire extra fingers (**Polydactyl**) in the hands or feet is incomplete penetrance. This is because some individuals which inherit this allele have ten normal fingers, while others have more than ten.

The expressive: It means an allele could produce a heterogeneous range of phenotypic types.
An example of this is pure insect for the recessive gene for the mutation of **eyeless** which gives phenotype with various ranges between the existences of normal eye to partial loss in the eye size in one or both eyes.

Genetics and the environment

Each living organsim has its own traits, which are inherited from the parents. It can be identify phenotypic traits through the study of the parents and analyse their genes. However, this determination cannot be accurate because the genes only determine what could be the trait and not really what will be, because some phenotypic traits depend on genetics and environmental factors and overlap between them. There are number of cases show that the effect of genes determined by various environmental factors, whether these factors surrounding the mother organism and inside her, to clarify this we give the following examples:

Example (1)

Genes responsible of the human body are affected by the quality of his food

The fat and slim characters are depend on the genetic bases. Controlling the body weight greatly influenced by the amount of food and other factors.

Example (2)

The impact of the environmental quality of the food as the gene responsible for the color of fat in Rabbits:

Building yellow fat in rabbits depends on a recessive gene (yy). Note that rabbits carrying this gene suffer from a lack of enzymatic and thus become unable to demolish the yellow colour which can be found in the carrots and in other plants. So when those rabbits fed on plants containing the yellow colour, then this colour will appear in their fat. If these rabbits are fed with colourless plants, then their fat will of course be white although the gene (yy) has not changed-only the food has changed.

The other rabbits that do not carry pure gene of yellow fat has the ability to partition the yellow colour, thus they will have white fat even though it was fed on a diet rich in yellow colour.

Gene Interaction

This is producing new phenotype by interaction alleles peculiar to different genes. There are two types of interactions:

1. Genetic interaction that leads to a change in the expected phenotypic ratio eg"**Epistasis**" which is the non-reverse interaction, such as the availability of gene interfering in or preventing another gene expression. The white colour **W** of the fruit in the pumpkins plant (**Squash**), superior to gene with yellow color of the fruit **Y**.

When hybridising white **WWYY** to another green fruit **wwyy** fruit, the first generation was white fruits. In the second generation the white color appeared in the ratio **12 white: 3 yellow: 1 green**. This ratio shows that parents are different in two pairs of genes. The father white-fruit carries yellow gene that did not show its effect, because of the presence of white colour gene which is superior. It is possible to explain how to get the phenotype ratio and the genetic ratio by using punnett square as follows:

	A white fruits plant	X	A green fruits plant
P1	WWYY		wwyy
		Meiosis	
G1	WY		wy
F1		WwYy % 100 White	

If they leave for self cross;

P2 ***WwYy*** ***X*** ***WwYy***

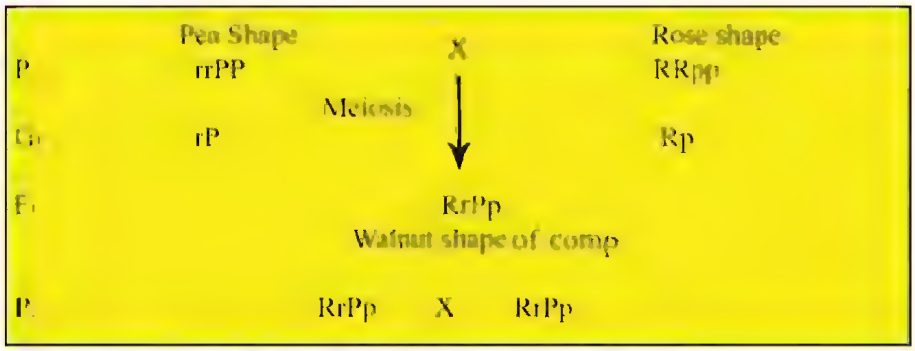
Figure 5.13 Different colored pumpkin fruits (for study)

G_2 / F_2	WY	Wy	wY	wy
WY	WWYY	WWYy	WwYY	WwYy
Wy	WWYy	WWyy	WwYy	Wwyy
wY	WwYY	WwYy	wwYY	wwYy
wy	WwYy	Wwyy	wwYy	wwyy

□=White ■=Yellow ■=Green

2. This is the genetic interference which does not lead to any changes in the expected phenotypic ratios. However, the members of the first generation posses new trait which is not available in the parents. With regard to the second generation, they will have two new traits not available in the grandparents. An example of this case is the shape of comb in the chicken. The rose shape for the comb is due to the gene **R** which is dominant over **r** for a single comb.

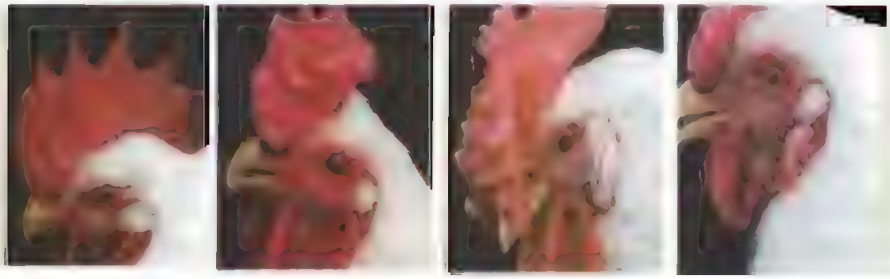
The pea shape of comb in the chicken is because of gene which is dominant **P** over allele **p** for a single comb too. When rose shaped parents are mated with a Pea shape, assuming both are pure, a new type appear in the first generation, known as walnut comb . When the members of F_1 are crossed between each other, F_2 shows the new type (Walnut and single) in addition to the grandparent's type as below:



The phenotype ratio for the second generation will be:

F2 rrpp 1 : rrPP 3 : RRpp 3 : RRPP 9

Single Pea Rose Walnut



Multiple alleles

This is the availability of alternatives or various alleles for the same gene, as a result of mutation happened the molecule of (DNA) genetic material. This cause variety in the phenotype, and they located the same genetical position on a certain chromosomes. We give some examples for multiple alleles:

Example 1: ABO system in Humans

There are three alleles controlled by the system, which are I^A, I^B and I^O. As we are aware that I^A and I^B are **codominant** but both of them is dominant over i . The two alleles I^A and I^B control forming two different type of enzyme which results in appearing two different molecules of antigens over the surface of the red blood cell. i allele does not cause activation any type of enzyme, so antigen will not produced as a result. The person which inherits two alleles of i , his blood group is **O**.

Blood Group (Phenotype)	Antigen on RBC surface	Genotype
A	A	(I^AI^A or I^Ai)
B	B	(I^BI^B or I^Bi)
AB	A,B	(I^AI^B)
O	--	(ii)

Table 5.3 Shows how three alleles could meet in the form of pairs and how to produce four types of blood groups.

Blood transfusion

The blood group **ABO** and **RH** factor must be known for both the donor and the **recipient**. This is because the red blood cells of some people may clump clearly and when mixed with samples of other donors. This was discovered by **Landsteiner** in 1900.

The basis for this clumping is the resulting interaction between antigene which is carried by red blood cell surface and what is contained in the serum of antibodies. Note that the relationships between them is shown in the below table.

Antigens are given by the letters **A** and **B** and the **antibodies** given by small letters **a** and **b**.

Blood Groups	Antigens on RBC surface	Antibodies in blood serum
A	A	Antibody b for antigen B
B	B	Antibody a for antigen A
AB	A,B	
O	--	Antibody a for antigen A Antibody b for antigen B

Table 5.4 Shows the antigens and antibodies according to blood types

In the light of the above information in the given table, it would be possible to decide the compatibility occur between the donor and the recipient in the transfer of blood groups **ABO** (incompatibilities) and the case when there would be agglutination between them.

Figure 5.14 Shows how the genetics have explain the compatibility or the mismatch in the transfer of blood groups ABO. (for study)

Agglutination not observed. **Agglutination observed.**

Donor	Recipient
O	O,A,B,AB
A	A,AB
B	B,AB
AB	AB

Donor	Recipient
A	B,O
B	A,O
AB	A,B,O

Example 2; RH antigens

This is one of the other antigens that show multiple alleles. It was discovered by two scientist called **Landsteiner** and **Weiner** in **1940**. It was given a great deal of attention and that of their direct emergence of a case of anemia for some newborn babies. The disease is called **Erythroblastosis Fetalis**. For this reason, the blood groups **ABO** and the **Rh** have to be tested on the verge of marriage. This is to exclude the emergence of this disease in their children and to take the necessary precautions.

The fetus who has **Rh+** and mother **Rh-** and their father are **Rh-** can be affected by this disease. The father passes this allele to the fetus because **Rh+** is dominant over **Rh-** so the embryo has become of hybrid genotype **Rhrh**. This kind of genetic units results in compatibility total immunity between the mother and the fetus.

If blood flow through the placenta which is defective for some genetic reasons and entered into the mother's circulation, the immune system of the mother will diagnose **Rh** antigens as foreign bodies, so it builds antibodies against them.

In the second pregnancy, these antibodies concentrate in the mother's system and when they pass through the placenta, of course enter the circulatory system of the fetus and start break-up of red blood cells. As a result this will cause loss of hemoglobin, causing anemia (jaundice).

There are about **10%** of the populations who have pregnancy with **Rh** incompatible. For several reasons, less than **0.5%** in fact produce **anemia**.

Usually the mothers with this kind of problem will be given **Anti-Rh** immediately after birth antimatter's (**Anti-Rh**) **Rh+**. These kinds of antibodies destroy cells of **RH+** type, which has passed to the mother's blood circulation. So she is unable to produce antibodies for the recipient.

Genetics Rh system

Preliminary genetic research led to belief that the human population there is only two alleles controlling the presence or absence of antigen. The scientists assumed that the allele Rh appoint an antigen on the surface of red blood cells and behaves as a dominant gene. The allele(rh) leads to the absence of antigen.

It has been found that **85%** of the population of New York City contains any antigen (**Rh+**); at the same time the remaining **15%** do not contain any antigen. I.e. (**Rh-**).

In the city of Basrah, it has been found in **1976** that **93%** of the sample studied possessed **Rh+** and **7%** of all was **Rh-**.

It has found that the negative type is less in the Eastern societies perhaps because of the election against negative alleles. This is due to the result of improvements to the tests necessary to set the presence of antigen. It became clear that genetics, which controls the **Rh** antigen, is rather more complicated than expected in previous time.

The scientist **Weiner** supposed later that there is a series of multiple alleles in a single location for **Rh** and that must be taken into account for these variations. On the other hand the scientist **Fisher** and **Race** that there was some sort of another alternative inheritance which includes three of the convergent genes associated with **C. D. E** and every one of them includes two alleles which have the responsibility of inheriting the **Rh** factors.

The term Linkage used to describe the genes located on the same chromosome, which is the first pair of the physical chromosomes for this group. The student can follow this table which simplified in problem solving and genetic-related.

Phenotypic	Genotype
Rh+	RhRh or Rhrh
Rh-	rhrh

Example (3) About the blood group Rh

Man descended his first birth in a family group **Rh+**. His father was an **Rh+** too, but his mother was with **Rh-**. This man married a woman with **Rh+**, but her father was **Rh-**. Predict the blood group **Rh** for his children.
Indicate the number of his children who will not be affected by the disease.

Conclusion:

1. The father of the man with **Rh+** and his mother **Rh-**, so the man is hybrid **Rhrh.**
2. The women is **Rh+** and her father **Rh-**, therefore she is also a hybrid **Rhrh**

	♂ Hybrid Rh+	x	♀ Hybrid Rh+
P	Rhrh		Rhrh
G	Rh, rh		Rh, rh
F	RhRh:	Rhrh: Rhrh:	rhrh

3 Rh+ : 1 Rh-

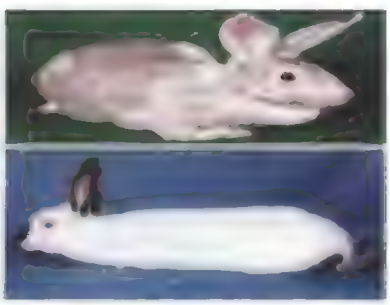
None of the children will be affected by the disease.

Example (2): Series of alleles in rabbit fur colour

The fur color is a classic example of multiple alleles or multiplier, where it can be seen the influence of the allele on the phenotypic directly with the naked eye, without having to use any technique for explanation. The fur color is controlled by at least four different alleles, which are (c^a, c^h, c^{ch}, C).

Note that the allele (C) is responsible for the gray colour (agouti). This allele has the full dominant over all the other three remaining alleles (c^a, c^h, c^{ch}). With regard to the allele c^{ch} in turn is dominant over the two alleles c^a, c^h. While c^h is dominant over c^a. So the order of dominance for these alleles would be follows: $c^a < c^h < c^{ch} < C$.

Some sources claim that there is incomplete dominance between alleles of c^h ,c^{ch} and between c^{ch} and c^a so when these two alleles meet in the same individual, between c^h and c^{ch} and between c^{ch} and c^a results in light gray colour.



Phenotype	Genotype
Agouti	CC, Cc^{ch}, Cc^h, Cc^a
Chinchilla	$c^{ch}c^{ch}$, $c^{ch}c^h$, $c^{ch}c^a$
Himalayan	c^hc^h,c^hc^a
Albino	c^ac^a

(Inheritance multi-genes) Quantitative Genetics

This is the transmission of genetic traits as a result impact cumulative or additive for the number of the genes in the cell. Most of the qualities in human are the qualities of multiple genes (**polygenes**) or **complex characters.** They greatly influenced by the genes and the environment as well. The character of multiple genes in human is the skin colour, eye colour, intelligence, blood pressure, body weight and total number of skin lines (**Total Ridge Count TRC**) in the fingerprints of both hands.

Note that the number of lines of fingerprints models are largely appointed by multiple genes as well as partially respond to the environment of the uterus and this is a **multi-factorial trait.**

It has been observed in some communities there are differences between the sexes in the distribution of installing these lines where the average number in the male sample **145** line, while the average number in a female sample **126** lines. These numbers can be different in some other societies.

The properties with multiple genes available in the other creatures is the seed colour in the wheat and the amount of production of seeds and fruits and the time required to reach maturity in plants. Also the amount of milk, meat, eggs, and the rest of the economically important traits in animals.

Figure 5.15 Eye color controlled by multiple genes (for study)

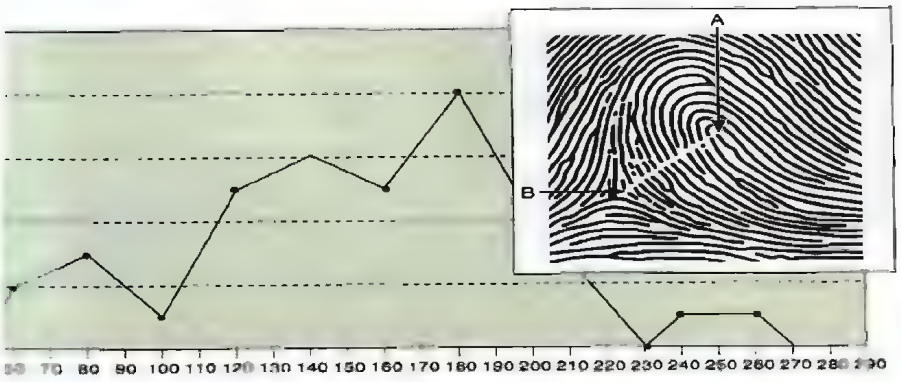


Figure 5.16 Anatomy of fingerprint and total number of lines in it (for study)

Concept of multiple genes

Multiple genes is defined as; having slight impact on the phenotype when a gene is alone. As it accompanies with a few or many other genes, it can control quantitative property. **Quantitative traits System** are differs qualities from Mendelian traits system or descriptive **Qualitative traits** as in the following:

Table 5.5 Comparession between quantitative and qualities traits

Quantitative traits	Qualities traits
1- controlled by more than one pair of multiple genes	Controlled by a pair of genes
2-Phenotypic model for members of the first generation will compromise between the parents.	Phenotypic model for members of the F_1 hybrid is similar to the pure dominant phenotypic model for the parents.
3-Its differentiation is continuously So the members of F_2 or following generations cannot be distributed to limited phenotypic groups.	Its differentiation discontinuous type. Thus F_2 or the following generations can be distributed to members of the to limited phenotypic groups
4-Access multiple genes is incomplete Therefore affected by the environment.	Access multiple genes is complete. Except in some cases it will be affected by the environment
5-The phenotypic ratio for the F_2 members with respect to bilateral hybrids is, 1: 4: 6: 4: 1.	The phenotypic ratio is 1: 3 3: 9

Measuring the effect of multiple genes (heritability coefficients):

Most of quantitative traits influenced by heredity and environment at various degrees, so researchers are interested in this area in measuring heritability coefficient (Heritability) for the quantitative trait for its outstanding role in estimating genetic improvement expected from the election.

The heritability coefficient is statistical measure shows the amount of variations in the population which is due to genetic factors between **0** and **1**. Approaching the value one indicates on the impact of genetics and vice versa for the impact of the environment. For example, heritability coefficient for prescription number of lines on equal to **0.66**. This means that the genes have additional affect have the influencing role in the expression of this trait.

$$\text{Heritability} = \frac{\text{Additive variation}}{\text{Phenotypic variation}}$$

This kind of inheritance can be explained by the following example:

If we assume that the inheritance of eye colour in humans is under the influence of a couple of alleles **AA** and **BB**. Then if a man dark brown (Black-eyed) **AABB** is mated to a woman with light blue eyes, then the eye colour for their descents will be as indicated in the following diagram:

Dark Brown (Black) eyed ♂	X	Light blue eye ♀
P	AABB	aabb
G	AB	ab
F	AaBb	
	Light Brown (Average)	

If the members of the first generation are mated to members of the same type in their genotype the phenotype in the second generation will be as follows:

1 Black (dark brown): 4 brown Moderate: 6 Light brown : 4 green (dark blue): 1 light blue.

Also genotypes for second-generation members will be as described in.

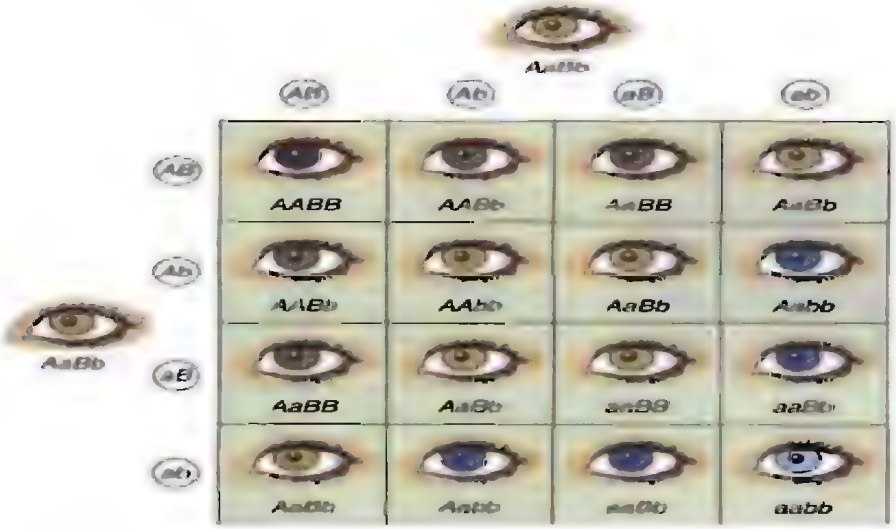
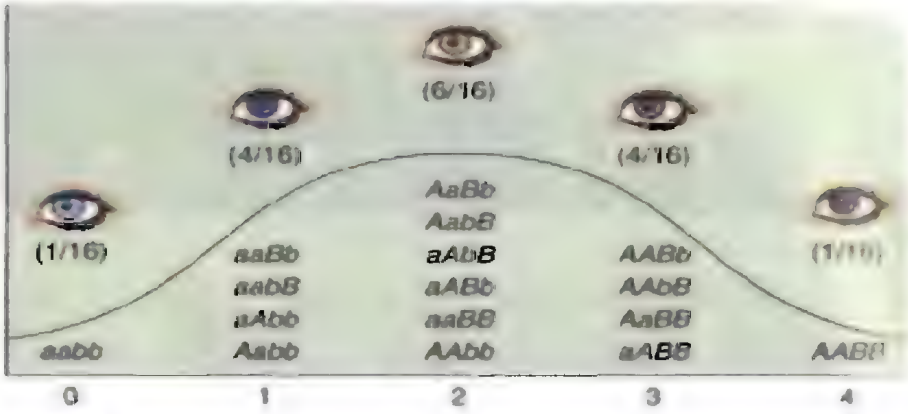


Figure 5.17

Variations in the eye color.

A. Model for two genes, each containing two alleles which are able to explain the existence of a five-color in the human eye.



B. Frequency distribution of eye color with a distribution of bell curve for the quantitative trait. (for study)

We note the followings from figure 5:17.:

1. The eye colour becomes black due to the presence of a couple of dominant alleles **AABB**
2. The moderate brown (medium brown) color appears when there are three dominant alleles and one recessive (**AABb**) or (**AaBB**).
3. The eye colour becomes moderate (light brown) when there are two dominant and two recessive alleles (**AAbb**) or **aaBB** or **AaBb**.
4. The eye colour appears deep blue or green when there is one dominant allele and three recessive **Aabb** or **aaBb**.
5. With regard to the light blue it is shown when there no dominant alleles (**aabb**).

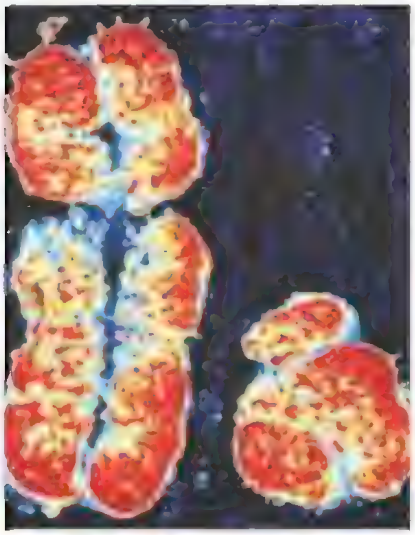


Figure 5.18 X and Y chromosomes during cell division (for study)

Sex and Genetic
Limitation and Determination of Sex

As we know the gamete contains half number of chromosomes, union takes place between male and female gametes at the fertilization to form new member which will be either male or female in normal case.

Limitation of sex in many of organisms (except micro organisms) due to the genes which are located on the **sex chromosomes**.

It's been found in **Dioecious** organisms (separate sexes) that male differs from female in chromosome structure, these chromosomes which include the difference called **Sex chromosomes** which are different in two the sexes, so can be **XX** in female and **XY** in male and conversely, the other similar chromosomes in male and female are called **Autosomes(A)**.

When the sex chromosomes are identical in one of the sex, it will give one type of gametes when it divides, this called **homogametic sex**. The other sex gives two different types of gametes and this called **heterogametic sex**. The following table is to identify the sex in the organisms which gives different gametes in its male or in female, that's because of the difference in the sex chromosome from the shape **XY** aspect or the number **XO**.

Notice the figure below which explains a mammal animal doesn't the chromosome **Y** (**XO**).

Figure 5.19 Animal (mole) without Y chromosome. (for study)

Identifying The Sex System
1.Males Give Different Gametes

XY males	XO males
Are found in human, other mammals, some insects and dioicious plants. Male produce two types of gametes; the gametes with X and gametes with Y chromosome. Female contain only X chromosome and after fertilization zygote contains XX (grow in female) or XY (grow in male).	Are found in some types of grasshoppers and in two types of mole voles, male has one less chromosome. The males produce two types of gametes.Gametes with X and gametes without X chromosome. The single sex chromosome determine the sex of male.

2. Females Give Different Gametes

XY Females	XO Females
is found in moth and most of birds.	is found in chicken and some butterflies

The chromosome **Y** is much smaller than chromosome **X** in human but it contributes with chromosome **X** in many of **DNA** sequences. This chromosome contains **sex determining region of the Y (SRY)** and also contains **azoospermia factor (AZF)**. This chromosome is important in development studies.

In some of twisted winged insects, such as bees, ants and wasp the sex determines by completely different procedure, so the unfertilized eggs hatches into males with haploid chromosomes and female with **diploid** chromosomes.

In some cases it has been found that the ratio between the sex chromosome **X** and the auto somes **A** determines the sex in Drosophila melanogaster. Noticed that the change in temperature controls the determination of sex in reptiles.

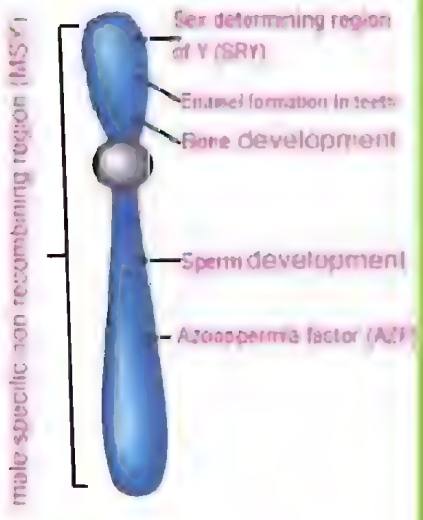


Figure 5.20 Male determining chromosome in human

In microbiology such as bacteria, some of them have got positive fertility factor (**F+**) it behaves as a donor in the operation of fertilization. The bacteria cell which hasn't got the factor (**F-**) it behaves as a recipient.

Sex linked traits in Drosophila melanogaster

These are the traits which express about the genes which are located on the sex chromosome. These traits differs from the other traits in main property that is represented at least by two genes in female and by one gene in male, that's because the number of the chromosome (**X**) in both sexes.

The first one who discovered the property of sex linked traits is the scientist **Morgan** (1910) when studying the genetic of the colour of eyes in Drosophila melanogaster, so he noticed that the trait of white colour of eyes is linked to sex and its recessive in respect to red eye and also noticed that's the reciprocal cross to these traits gives different results.

Example 1

Female of Drosophila melanogaster which have pure red eyes crossing with male which have white eyes, the first generation were male and female red eyes by the ratio is **1:1** and when the first generation were left to self conjugation, some of the product was male white eyes.
What are the genotypes for the parents and the member of two generations (F_2, F_1)?

* The gene of red colour eye is dominant over the gene of white eye.

Solution:

The gene of the eye colour in drosophila is linked to sex chromosome, so it should always be sketched on that chromosome which is defined by **X**. It refers to the gene of white eyes color (recessive traits) by the letter **w** from the word white, it refers to the gene of red eyes colur (dominant) by the letter **W**, can explain the result of this crossing as follows :

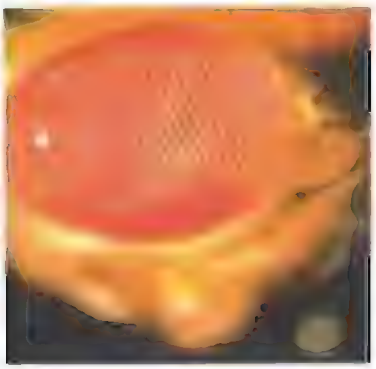


Figure 5.21 Difference between eye colurs of fruit fly (for study)

	Female pure red eyes	X	Male white eyes
P:	X^WX^W		X^wY
G:	X^W		X^w . Y
F_1	X^WX^w	+	X^WY
	Hybrid Female red eyes		Male red eyes
	1	:	1

	Hybrid female red eyes	X	Male red eyes	
P_2	X^WX^w		X^wY	
G_2	X^W . X^w		X^W . Y	
F_2	X^WX^W : Female red eyes pure	X^WY Male red eyes	X^WX^w : Hybrid female red eyes:	X^wY Male white eyes

The results of this crossing differs to cases for the two alleles, one of them is dominant and the other one is recessive which are available on the two somatic chromosomes (Mendel genetic) as follows:

1-The rates in the second generation F2, are 3:1 in both cases but with regard to the sex linked traits, the appearance of recessive trait which are (white eyes) restricted to the male only.

2-Half of the male have white eyes and the other half have red eyes with regard to this sex linked trait, also the results differs when conjugation female that has white eyes with male that has red eyes as in example (2).

Example (2)

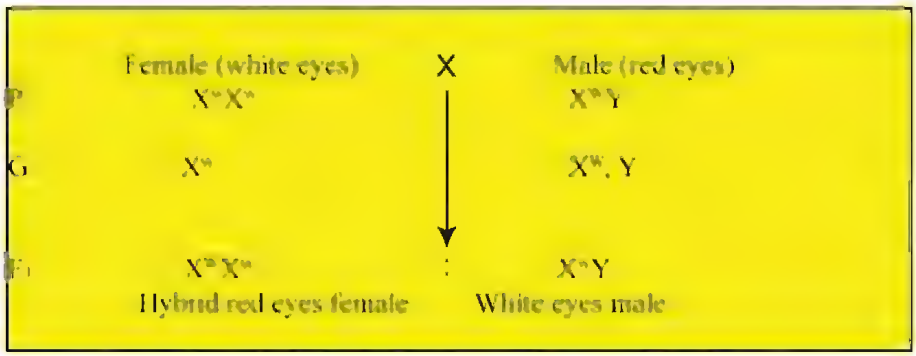
Reciprocal Cross for the above case in example (1)

When crossing female of Drosophila melanogaster (white eyes) with male (red eyes), the members of the first generation were females red eyes and males white eyes, when the members of (F_1) conjugated between them, the two sexes appeared in (F_2) by the ratio **1:1**.

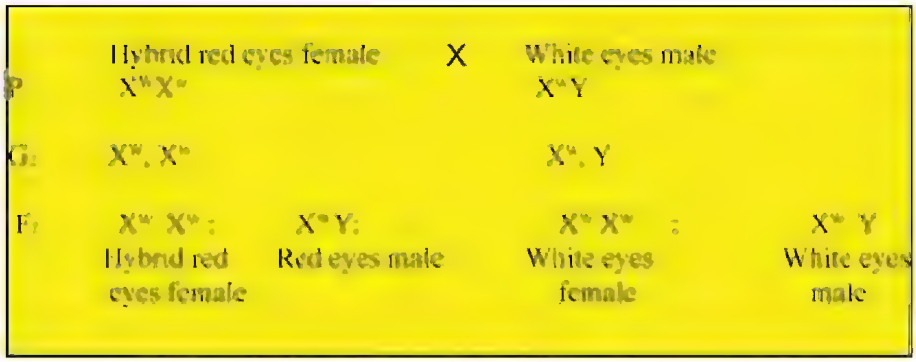
What are the genotypes for the parents and for the member of (F1) and (F2)? Given that the gene of white eye trait is recessive towards the of red eye trait.

Solution

We refer to a recessive white eyes gene (w) and the symbol for the dominant red eye gene (W). We can explain the products of this reciprocal cross as follows:



When crossing the member of the first generation (F1) with each other ,we get the following:



We conclude the followings from this cross:

a. Differences of phenotypes for the first and the second generation one from the results of the example (1) and from the results of Mendel's traits.

b. The white eye mothers transferred their traits to the males of the first generation members, also the fathers transferred their trait of red eyes to the females, and this type of genetic is called **Criss-cross inheritance**

c. In the second generation we got the ratio (1:1) in each of the sex with regard to the colour of eyes instead of the known ratio for the Mendel s traits which are (3 dominant: 1 recessive).

Sex linked traits in human

1. Colour Blindness

The cause of this disease is recessive, sex linked gene (X^c) taken from the word (colour) and the ratio of this disease in male more than female by 20 times. The effected person feels inability to recognize between the two colours red and green (fig 5.22). That's why he has to be careful when driving a car. In the following the explanation of genotypes and phenotypes for this disease.

Phenotype in woman	Genotype in woman	Phenotype in man	Genotype in man
Not affected	X^CX^C	Not affected	X^CY
Carrying the gene of the disease	X^CX^c	------	------
Affected	X^cX^c	Affected	X^cY

2. Haemophilia

The affect of this disease are described as inability of their blood to clot when having a cut in the skin, that's because of difficulty to breaking the blood platelets, this because of antihemophilic factor which is called Factor VIII is missing. Missing this factor is caused by a recessive sex linked gene X^h. The genetic of this disease is similar to the genetic of color blindness except the pure female in the gene of the disease (X^hX^h) may die in the early stage of embryonic growth.

Phenotype in woman	Genotype in woman	Phenotype in man	Genotype in man
Not affected	X^HX^H	Not affected	X^HY
Carrying the gene of the disease	X^HX^h	affected	X^hY
Affected dies in the early stage of embryonic growth	X^hX^h	----------	----------

3. Genetic of dominant sex linked trait in human

Some people have decrease in phosphor level in the blood serum. The cause of this disease is a dominant sex linked gene (X^D), the normal person has got recessive gene (X^d).

Practical example

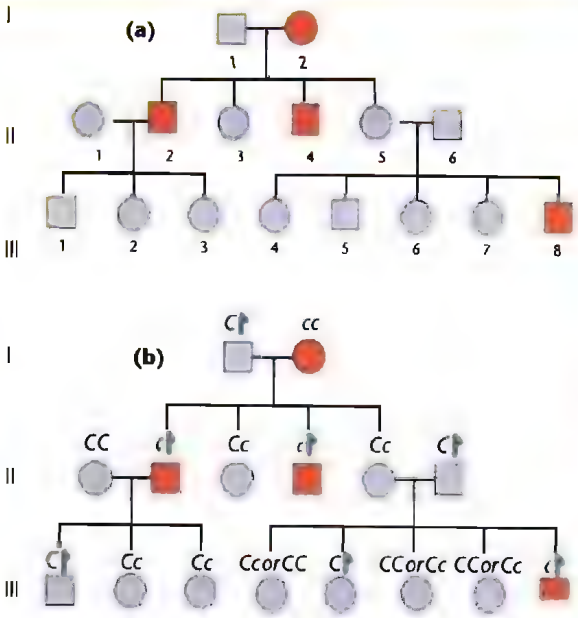
Woman affected by Rickets her mother was affected, but her father was not affected, she got married to a man (not affected) and she had four children, there were a boy and girl are affected. What is the genotype for each member of this family?

Conclusion:

Some children are affected and some are normal that means the mother is hybrid in the gene of the disease, because if she was pure, then all the children would be affected. Also we conclude that woman is hybrid from her father (not affected).

Solution

	Hybrid female affected	X	Male not affected	
P1	$X^{a}X^{+}$		$X^{a}Y$	
G1	X^{a} X^{+}		X^{+} Y	
F1	$X^{a}X^{a}$ Female affected hybrid	$X^{a}Y$ Male affected	$X^{+}X^{+}$ Female not affected	$X^{+}Y$ Male not affected



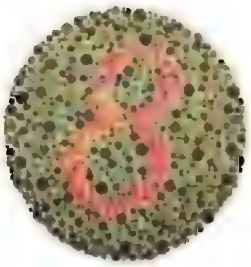


Figure 5.22 (for study)

a) Pedigree of color blindness (sex linked trait)

b) Shows the probable genetic trait for each member.

Anyone who infected by color blindness cannot see number "8" but see number "3" from the colorfull circle

Sex-influenced traits

The phenotype for the trait depends on the sex of the person. Hybrid express about phenotype in sex and the alternative type in the other sex example for that is baldness in human.

It is known that this trait is controlled by the gene **B** which is available on the body chromosome and its dominant in male, the baldness produces in male by two genotypes **BB** and **Bb** but it doesn't produce baldness in female, except in the case of **BB** although of that, the effect of it, isn't as much as in male and it express about it in later stage of the age. The appearance of baldness depends on concentration of male hormone.

Phenotype in woman	Genotype in woman	Phenotype in man	Genotype in man
Bald	BB	Bald	BB
Normal(carrying the gene)	Bb	Bald	Bb
Normal	bb	Normal	bb

The other sex- influenced traits are the trait of length and shape of the feathers in chicken, horn in sheep and the colour of the hair in **Ayrshire** cow. There are two offspring, one of them is red and the other one is spotty by black and white, and the last type is more common in male.

Sex-limited traits

We have known when studied the recessive sex-linked genes will be in male more than in female. Any there are other factors can affects the express of the gene according to the sex (male or female) in a different ways. Sex – limited trait due to a gene affects the structure or function of the body which is available in male only or in female only. This kind of gene can be located on body chromosome or linked to sex. Understanding the sex-limited genetic is important for people who is specialist in looking after animals, for example producing milk in cows affects one sex only but any of the parents can transfers the genes which controls these traits.

Another example in human is the voice, growing beard, the size of breast and sudden raise in blood pressure at the time near giving birth for some pregnant women. In general female don't have growing beard because its disability to secrete the essential hormones for growing hair in the face.

Chromosome Mapping

The farther apart two genes are located on a chromosome, the more likely a **cross-over** occur. The greater the percentage of **F2** offspring showing recombinant traits, the farther apart the genes for those traits must lie on a chromosome.

Researchers conduct breeding experiments and use the resulting data to prepare a chromosome map. A chromosome map is a diagram that shows the linear order of genes on a chromosome.

Alfred H. Sturtevant, one of Morgan's students, made the first chromosome map for flies, To prepare his map, Sturtevant compared the frequency of crossing-over for several genes. The percentage of crossing-over for two traits is proportional to the distance between them on a chromosome. Sturtevant defined one map unit as a frequency of crossing-over of 1 percent.

Linkage and Genetic Crossing over

Linkage is a case of availability of two or more of non allele genes which tend to inherit with each other. The linked genes has got its location on the same chromosome, it doesn't distribute freely but it can separate from each other by **Crossing Over** which happens through **Prophase I** stage in first meiosis which the two homologous chromosomes exchange some parts including the molecule of **DNA**.

This exchange happens between the two non-sister chromatids for that identical pair of chromosomes, it doesn't produce new gene and it doesn't remove old genes, but rearrange the alleles in one of the sexes or in both.

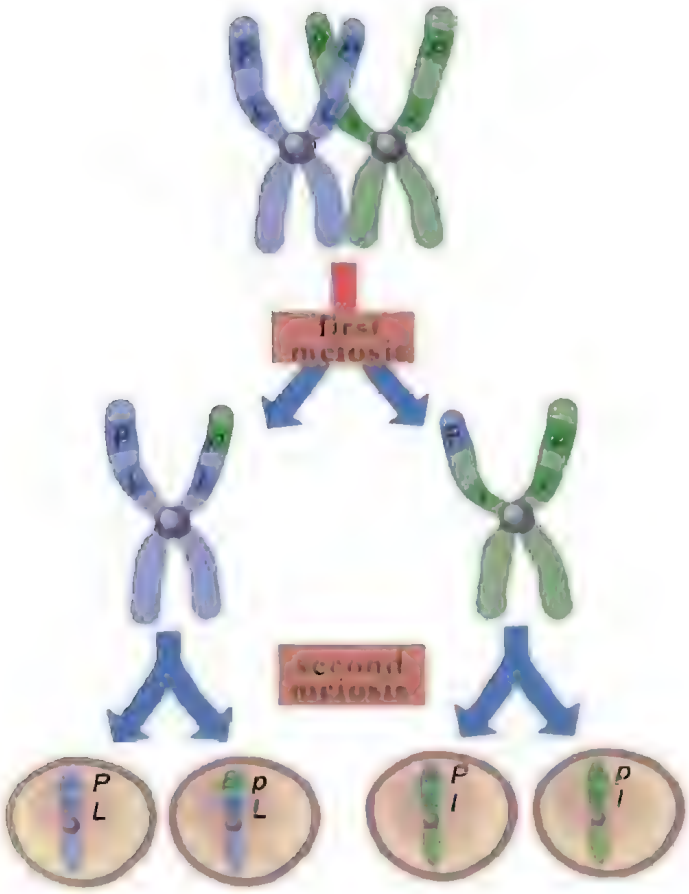


Figure 5.23 It shows how genetical crossing over takes place (for study)

Discovering the phenomenon of **Crossing over** by the scientist Morgan (1910) helped in explaining the results of many traits which has heredity procedure different than Mendel's ratio. As we know that these Mendel's ratio applies to the traits which its genes located on different chromosomes, that's why it distribute freely at gametes formation, but when these genes are located on the same chromosomes (Linked) its behaviour will change, so it doesn't distribute equally to the gametes, then we get different phenotypic - ratio to the one we got in test cross for (Dihybrid Cross).

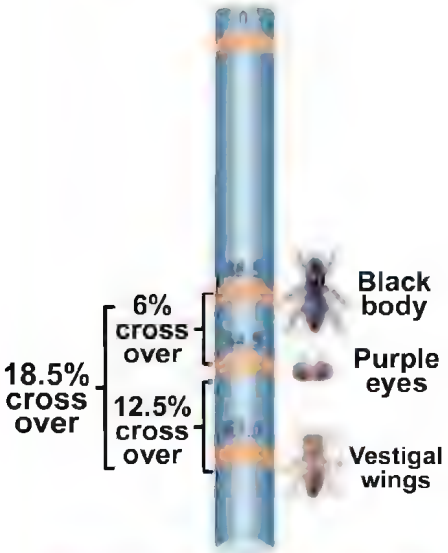


Figure 5.24 Show three genes on a chromosome of fruit fly including distance between them (for study)

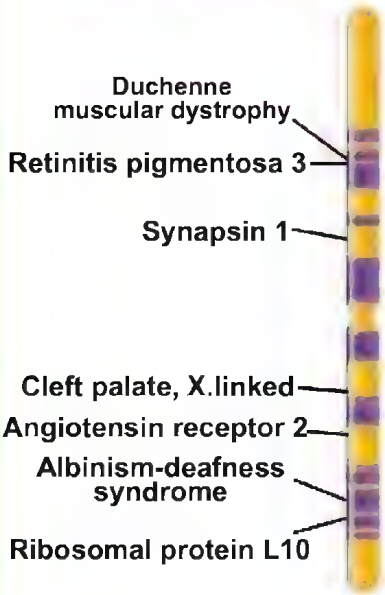


Figure 5.25 Gene map for X chromosome in human.Shows the genes which cause different disorders (for study)

So in this case we get two big ones are the product of uniting parents gametes and two small ones are the of product of recombinations.

We get the value of Crossing-over as follows:

$$\text{The value of Crossing} = \frac{\text{number of recombinations X 100}}{\text{the total number of offspring individuals}}$$

The product will be by percentage (%).

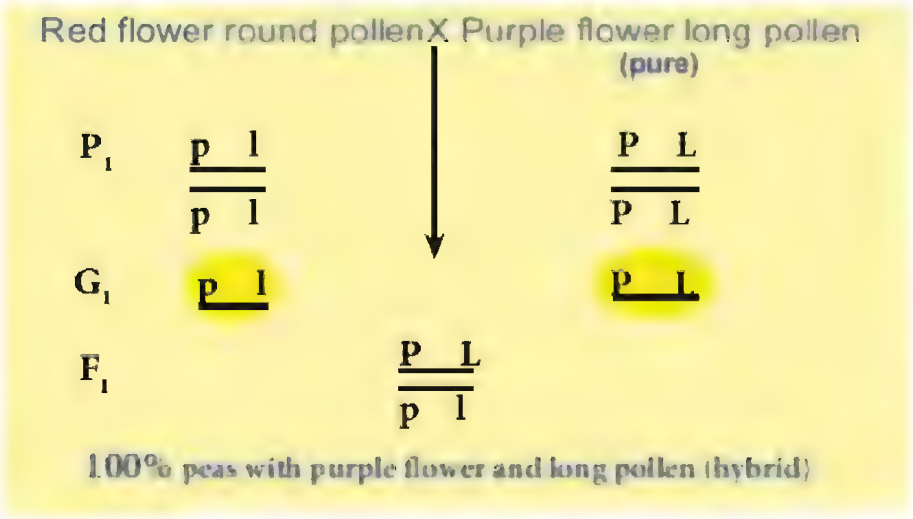
Map unit or **Centimorgan** is used to measure the distance between the genes on the chromosome and each of them represents the value (1%) from the Crossing between two genes. The amount of crossing or the seen recombination's proportional with the distance between two certain genes on the chromosome, so if this distance gets bigger, then the possibility of crossing is bigger, the genes which are close to each other on the same chromosome are hardly connected to each other, this notice was developed by the scientist Morgan which led him to put the theory of longitudinal order for the genes on the chromosome which led them to put the genetic maps for the chromosome.

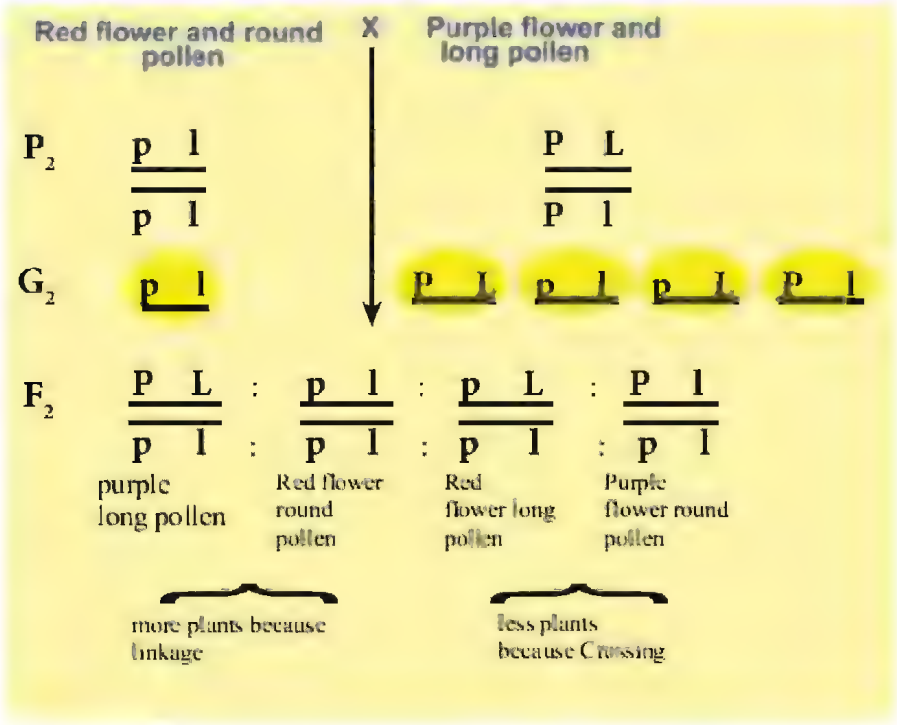
Also notice the map of the genes for chromosome **X** in human. This was put by using some new techniques. The percentage of crossing between the genes is affected by many genetic and environmental factors such as chromosomal mutations like Inversion and also chemical mutations and selection and sex, age, temperature and the x-rays.

Example;

Linkage and GeneticCrossing

When crossing the plant of **Sweet peas** with purple flower (**P**) and long pollen (**L**) with Sweet peas with red flower (**p**) and round pollen (**l**) all the member of the first generation were plants with purple flowers and long pollen, this result seems normal, because as we know that the traits of purple colour and long pollen are dominant on the traits of red colour and round pollen. But the ratio of the second generation is not identical with the phenotypic - ratio (**9:3 :3 : 1**) which is particular by di-hybrid, also when using test crossing we don't get the phenotypic - ratio and genotypic - ratio (**1 : 1 :1: 1**), that's means the two above genes are linked and in this case, can draw these two genes on the chromosome to recognize them from the Mendel's genes which is each of them is located on a different chromosome as follows:





The above explains the different type zygote **PL//pl** didn't produce the expected gametes in equal ratio. It produced parent's gametes **PL** and **pl** by higher ratio from the produced gametes of crossing **pL** and **Pl** that the last one gave less number of individuals. The linkage always tends to keep the parental combinations for the genes by fixed ratio nearly for any two linked genes.

Cytoplasmic inheritance

All the genetic information is coded in the molecule of **DNA** which is available in the chromosomes in **eukaryotes** organisms. According to this, can predict inheriting the traits in the families by knowing the behaviour of chromosome during division. But the **DNA** is not only available in the chromosomes, it is also discovered in the mitochondria, green plastids, base body for flagella and that was in the beginning of sixties. This discovery explains some aspects of cytoplasmic inheritance or (**External nuclear inheritance**) which is non-Mendelian inheritance; it includes transferring genetic information through auto-multiply for the cytoplasm organelles such as mitochondria, green plastids and others. The molecule of cytoplasm **DNA** shows a clear differences in nucleotides sequence from nucleus **DNA** ,so it's divested of protein, same as in the molecule of **DNA** in **Prokaryotes** like bacteria, virus. The multiplying of molecule of **DNA** for cytoplasmic organelles is similar to multiplying in prokaryotes, the studies showed its ability to do the genetic expression.

Kappa particles in Paramecium

Some descents of paramecium (**Orillia**) has the ability to secrete poison which distributes in water media and its called **Paramecin**, it kills the member of other descents which belongs to the same type when they present in the same media, it explodes the food vacuoles for the sensitive paramecium which swallows it.

The paramecium who produces this poison called (**Killer**) and the paramecium who dies because of it called (**Sensitive**). In the cytoplasm of killer paramecium, it's been found that small particles called **Kappa particles** which is similar to bacteria and it may contains a certain swallowed viruses. One of the theory points out that these viruses reproduce through multiplying, and then they produce poison which releases to kill the sensitive chains.

Kappa particles contains **DNA** and protein, each paramecium cell contains **100-200** particles, its present in the cell permanently depends on a dominant nucleic allele **K**, the paramecium will be killer when it contains kappa particle and the dominant allele **K** in the two cases (**Kk** and **KK**) and will be sensitive in these two cases:

1-When the gene is recessive (**kk**) even if it contains kappa particle, it can't keep them, so it lose them after a few division.

2-When the gene is pure and dominant (**KK**) or hybrid (**Kk**) that s in the case of kappa particles not present, so the dominant allele (**K**) can't produce bacteria kappa, only when there is a little part of it in the cell.

After the conjugation is completed, it produces two killer descents that mean the trait of kill inherits through cytoplasm.

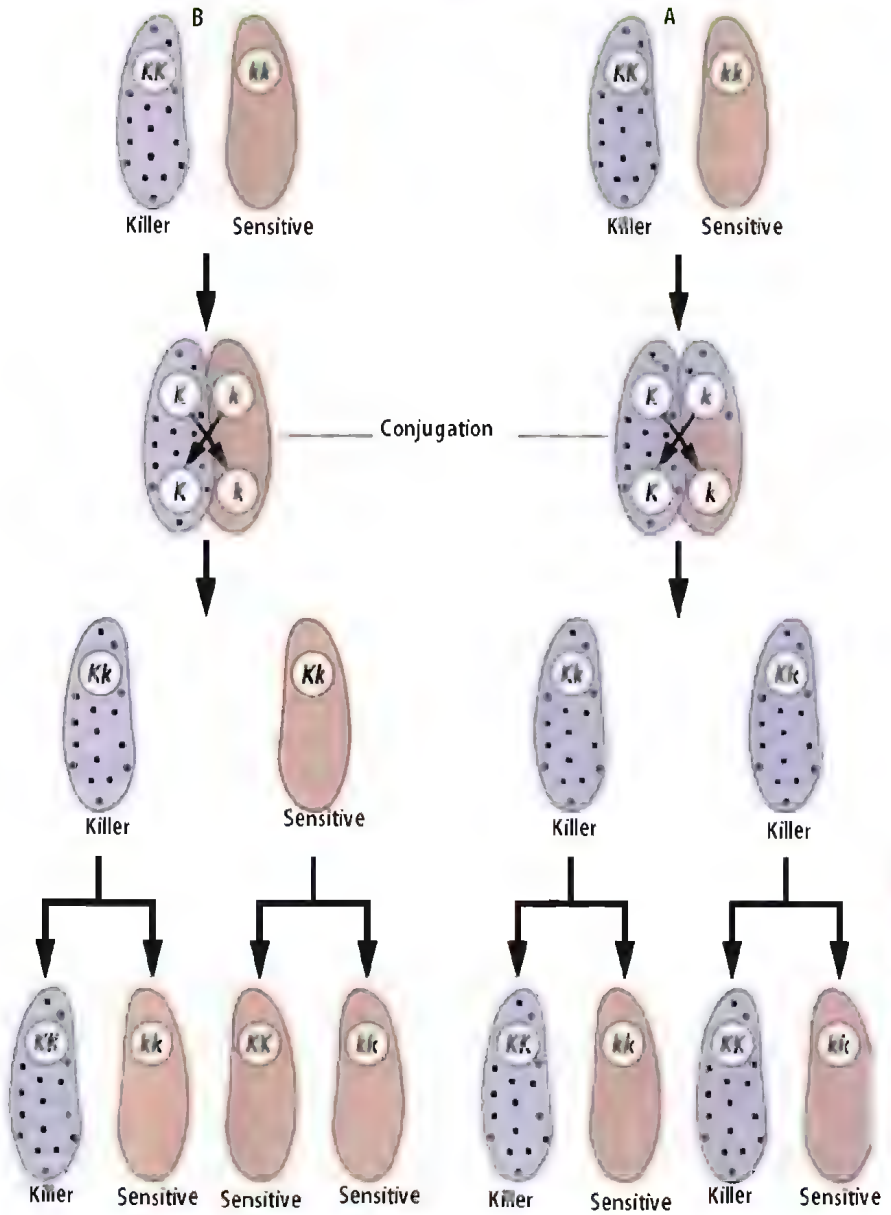


Figure 5.26
Cytoplasmic exchange happens (A) or doesn't happen (B). The case(A) happens when the time of conjugation between the two descents the killer and the sensitive is enough to allow exchanging big amount of cytoplasm between the two conjugated organisms, also to exchange the nucleic material.

When a killer one conjugates with a sensitive one in suitable condition so (avoid killing the sensitive one) exchange of the nucleic material happens without exchange in the cytoplasm (because conjugation period is short) (case B) and after the conjugation is completed.

The sensitive one gives sensitive descent which carries the dominant allele in the case of hybrid (**Kk**) but is missing kappa particles, the killer one gives killer descent (**Kk**) which carries the dominant allele and kappa particles, that means the trait of kill doesn't inherits through the nucleus, the produced descent from the killer one inherits kappa particles, meanwhile the descent of sensitive one doesn't inherits it, because the exchange of cytoplasm doesn't happen, another example for cytoplasmic inheritance in animals is the effect of genotype for the mother to point out the side of spiral the **Limnaea**.

Mutations

Mutation is sudden change in succession of nitrogen bases of a gene or of a molecule of **DNA**; this change is associated with appearance of new phenotype and genotype on the base of the quality of cells. There are mutations happens in the **germ cells** which is represented by the gametes of organism, the mutations of reproductive cells don't effect the organism itself but it may transfers to his children. There are mutations happens in the **somatic cells** of the organism then effects it, for example some types of skin cancer and blood cancer in human, this type of mutation doesn't inherits.

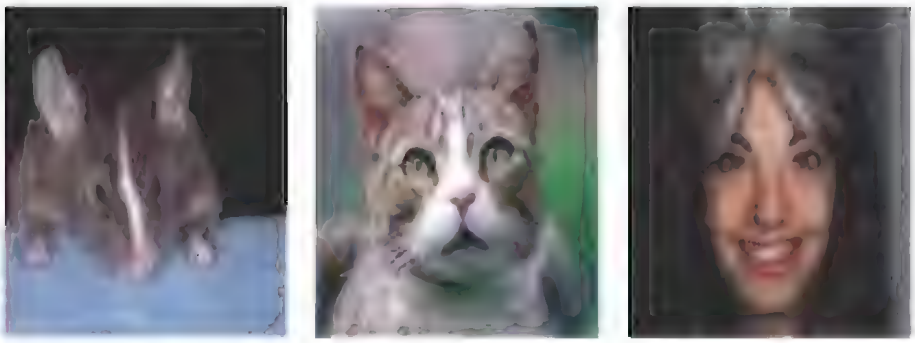


Figure 5.27 Mutation causes the similareffects in different organisms.

A) Mutation in mouse
B) Mutation in cat
C) Mutation in human (for study)

Mutations can be harmful as in the case of wings reduction in Drosophila melanogaster, shorten legs in sheep and many of diseases and **syndromes** in human, or can be **lethal** which leads to the death of embryo before birth.

Some mutations lead to useful phenotypes for organism, the organisms with useful mutation may have better chance for adaptation, reproduction and survive, so these organisms can be very important economically such as the mutation which leads to increase the animal and plant production and improve the quality.

Mutations can be represented in changes in certain chromosome this called chromosomal mutation or in certain nucleotide this called genetic mutations.

First: Chromosomal mutations

Chromosomal mutations divide into two main types:

1. Mutations because of changes in the number of chromosomes:

A. Aneuploidy, in this case there is one missing chromosome or one extra chromosome.

B. Polyploidy, this is an increase in complete chromosome group so the organism has triple-chromosome(3n).

2. Mutations because of changes in structure of chromosomes:

A) Change in the number of genes that includes **deletion** which means losing part of chromosome.

B) Change in the order of genes that includes **inversion** which is part of a certain chromosome breaks and reverses, then unites again with the chromosome itself and the transition which part of a certain chromosome breaks and unite with another not identical chromosome.

Some chromosome mutations are the loss or gain of entire chromosomes. The mutation that gives a person three copies of chromosome **21** results in **Down Syndrome**. The mutation which provide a certain person by chromosome added to chromosome pair number **21** is produced from Non-disjunction case this chromosome doesn't separate of the other one during meiosis, this leads to that one of the gametes contains an extra chromosome, at the same time the other one is missing this chromosome and this case called **Down syndrome**.

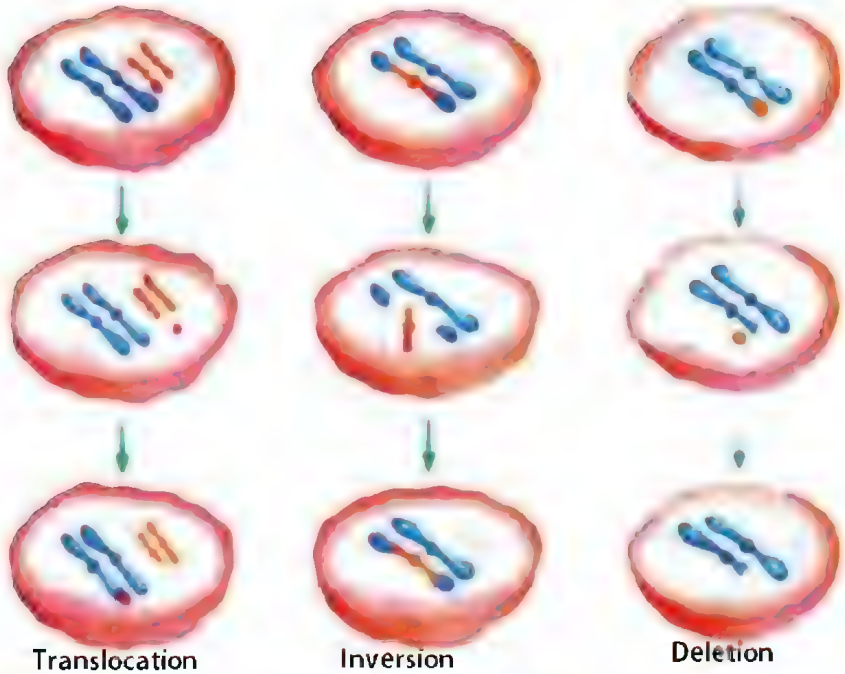


Figure 5.28 Chromosomal mutations (for study)

Second: Genetic mutation includes two types:

1-Point mutations:

It is the product mutation from deleting or adding or exchange one nucleotide with another one which belongs to one genetic location (**Locus**).

1- Deleting mutation: In this one nucleotide will be missing from a certain gene. This deletion leads to incorrect combination for remaining **Codons**, this called **Frame** shift **mutation** which leads to change all the amino-acids which locates after it (**A**). This mutation may leads to dangerous affects in the function of protein.

2- Insertion Mutation: This is to insert one nucleotide into a certain gene which may leads to **Displace Mutation** too.

3- Substitution Mutation: One nucleotide replaces with another one (**B**). If this Substitution happens in a certain codon, the amino-acid changes. There are many types of substitution mutation as follows:

Figure 5.29: (21) numbered chromosome repeated three times in down syndrome (Trisomy) (for study)

A- Missense Mutation.
B- Neutral Mutation.
C- Silent Mutation.
D- Nonsense Mutation.

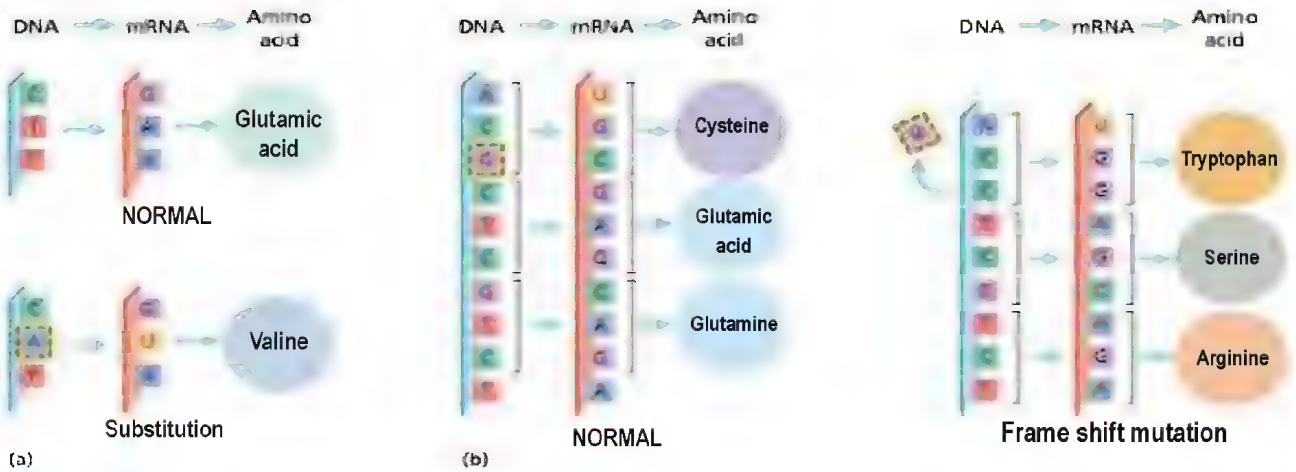


Figure 5.30 Gene mutation (for study)

A) In a substitution mutation, one nucleotide replaces another, forming a new codon that may signal the insertion of the wrong amino acid.

B) Deleting a nucleotide causes all subsequent codons to be incorrectly read, resulting in a frame-shift mutation. Adding a nucleotide shifts the codon grouping too, and causes misreading.

2- Duplicate Mutation

This includes affect more than one pair of nitrogen base for the gene, this happens through repetition of copying part of gene.

Average of occurrence mutation:

Most of organisms have got many genes, so the possibility of occurrence of mutation in one of these genes is very big. It's been known the average of mutation for the one gene in drosophila melanogaster is nearly 10^{-6}-10^{-5} so once for each 100000 million gene in one generation.

The total average of mutation in these insects is around **1% - 3%**. The average of mutation differs from gene to another in the same organism.

This average may increase when an exposure occurs to some **Mutagens** like radiation with high energy such as ultra violet rays and ionic radiation like x-rays or some chemicals like nitric acid, metallic salts and formaldehyde. It is clear that a number of known chemical materials can be **carcinogenic**.

Anti-mutagens

Because of the problems which mutation causes, the scientist have found recently anti-mutagens material for some mutations:

1) Bio anti-mutagens: These are stopping factors, it has role within multiplying the DNA or other factors which has role within the operation of repairing the damage.

2) Des-mutagens: This is like finding anti-material which works directly on mutagens such as anti-oxidation or finding Blocking Agents.

Human genetics

Despite of human genetics regards as the oldest branch of the practical genetics, and the human species (**Homo sapiens**) is most important target to study the genetics, but this branch developed slowly comparing by the other branches of genetics, that's because of many difficulties which facing the researches in this field and they are as follows:

1- The small size of the human families don't allow all the possibilities to appear, so it is difficult to make sure of the purity of the parents traits, so the big size families are more desirable in the genetic studies, but the number of the biggest human families is much less than the right number to put genetic ratios statistically testable.

2- The age of one generation since the birth until it reaches the age of adolescence are many years, so following the traits in the next generation takes long time.

3- The marriage in human is regarded as private issue which is impossible to control it or direct it according to the marriages which are controlled by experiments.

4- Many of human traits are not controlled by Mendel's genetics but they are controlled by non-Mendel's genetics such as an accompanying dominant, incomplete validity, interference the genetic action, multi genes with an accumulated affect which is impossible to study the effect of each one individually.

5- Large number of chromosomes in human comparing to the other organisms.

Studying the human genetic depends on the following:

a- Noticing appearance or disappearance the traits in the members and the relatives through generations by drawing the family tree and collect statistical data for one family and many families with the relation to the studied traits.

b- Studying the changes in the genetic frequencies and the interference with the environment which is regarded as important database for surgical medicine.

c- Dependency by modern molecule techniques through knowing the nitrogenous bases successions for the gene and link it by the function of that gene.

Pedigrees

Pedigree is a diagram shows the producer of a certain trait's genetic throughout many generations. The squares in this diagram refers to males, the circles refers to females.

• The square or the dark circle means the presence of the trait or the case with the person in a certain generation and vice versa for the light colour symbol.
•The horizontal line which connects the male to the female refers to the marriage.
•The vertical line refers to the children which have been arranged from left to right according to the order of the birth disrespect of the sex.
•The Roman numbers refers to concession of generations.

The four members in the fifth generation for the above pedigree are called **Carriers** for the gene, because they have one recessive allele only but they are not affected by the disease, but each family of them have the ability to transfer it to his son and his daughter by concession (from left to right).

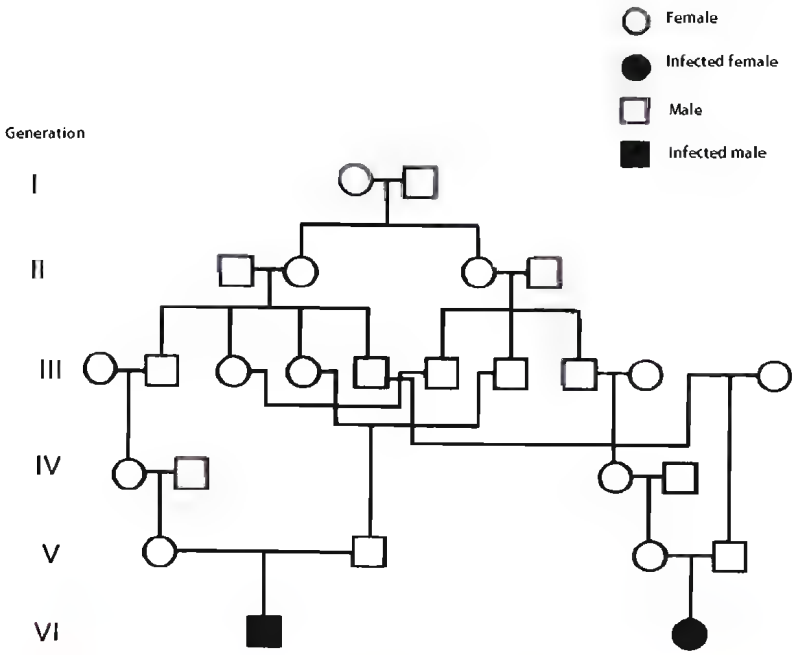


Figure 5.31 Pedigree show a disease that transmitted by a ressesive gene. (for study)

Inheritance of some body traits and disease abnormalities in human:

The people who are interested in genetic may know the genetic of some traits and the genetic abnormalities through analysing the patterns of inheritance, so analysing the expression about the genes throughout the generations by the pedigree. The standards of dominant traits which are the responsible gene for each trait is located on body chromosome.

1- The trait transfers in male and female by equal frequency.
2- The consecutive generations are infected.
3- Stopping the transfer after the generation which there isn't any affected one.

The standards of the recessive traits are the following:

1- The male and female are frequently affected at the same level, and the affected members can transfer the gene except in the case of death before the age of adolescence.

2- The traits can disappear for number of generations.
3- The parents of the affected person are heterozygote or carrier of disease.

The effect of genetics is not limited to appearance or disappearance of some traits only, but extends to the function of some organs and their preparation to get affected by certain abnormalities which transfers from the parents to the children in an identical form for other traits, example for that poly sacs in kidney for the dominant gene which causes that and the disease of cystic fibrosis for the recessive gene which causes that (table 5-6).

	Dominant Traits	Recessive Traits
1	Achondroplasia	Normal case
2	Brachydactyly	Normal case
3	Breast Cancer	Normal case(not affected)
4	Cleft chin	Round (no presence of Cleft)
5	Freckles	Clear
6	Free ear lobe	Stuck ear lobe
7	Presence of Dimples in the chin or cheek	Round (no presence of dimples)
8	Widow's peak	Straight
9	Huntington disease	Normal case(not affected)
10	Hypercholesterolemia	Normal case
11	Phenyl thiocarbamide	Not tasted
12	Polycystic Kidney disease	Normal case
13	Polydactyly	Presence of 5 fingers in hand or foot
14	Normal case	Alkaptonuria
15	Normal case	Non ability to coordinate movements (Ataxia)
16	Normal case	Cystic Fibrosis
17	Normal case	Tay-Sachs disease
18	Normal case	Galactosemia
19	Normal case	Phenylketonuria
20	Normal case	Thalassemia major

Table 5-6 Some Traits (Dominant, Recessive) in human.

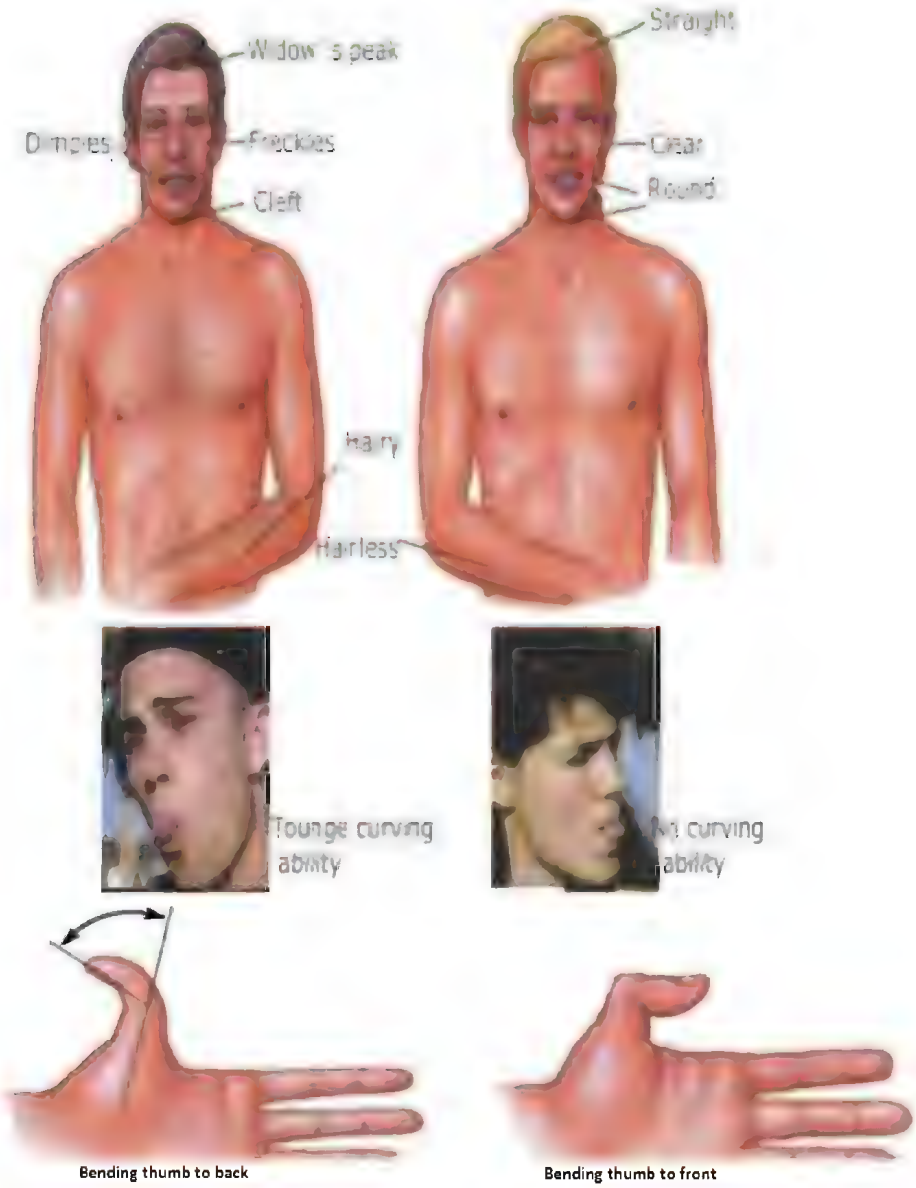


Figure 5.32 Some common genetical traits in human (for study)

Human Chromosomes

The chromosomes which are not directly related by determination the sex in human are called Autosomes and they are 22 pairs and the remaining pair as we know it represents the sex chromosome (one pair represents the sex).

Chromosomes of human may differentiate according to centromere location to the following types:

a- Metacentric Chromosome; centromere is located at the centre and the locus of chromosome at the same size.

b- Submetacentric Chromosomes; centromere is closed to one of the poles and locuses are in different sizes.

c- Acrocentric Chromosome; centromere more closed to one of the poles and look as "I" during cell division.

d- Telocentric Chromosome; centromere located at one of the poles.

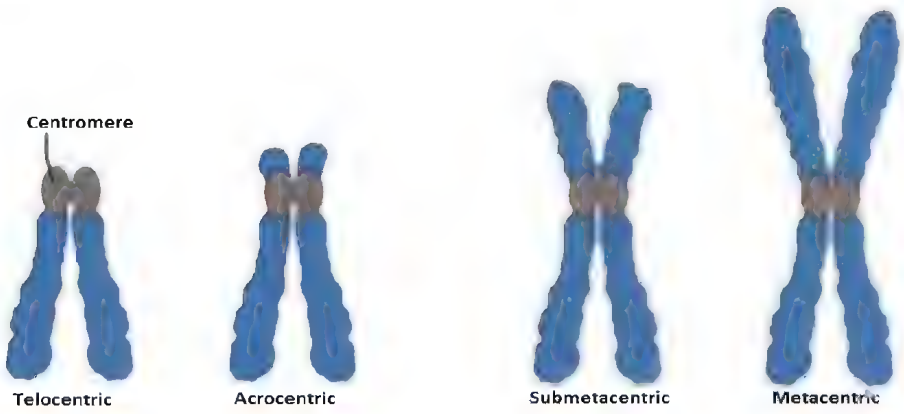


Figure 5.33 Types of chromosomes according to centromere positions

On the bases of the length of chromosome and centromere's location, the chromosomes of human can be ordered in 7 groups of Autosomes from **A - G**, and one pair of sexual chromosome either (**XY**) or (**XX**). On that base so the 23 pairs of chromosomes in body cells divides into the following:

Chromosome	Group
1-3	A
4,5	B
6-12	C
13-15	D
16-18	E
19-20	F
21-22	G
XX and XY	X

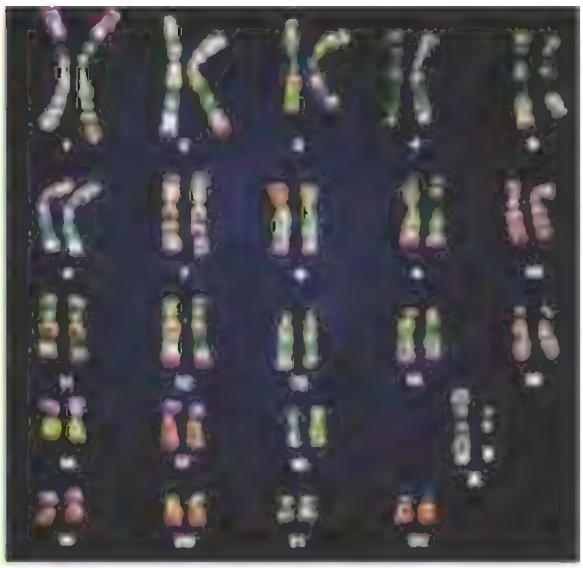


Figure 5.34 Chromosomal system of a normal male embryo (for study)

Diagnosing the genetic diseases

People who have got family history in getting affected by a genetic disease usually have the genetic examination, especially before having children, *there two methods to diagnose:*

a- Method of **Amniocentesis**.
b- Method of examine of **Chorionic villi** which are located in the lining of uterus.

Reducing the symptoms of some genetic diseases

That can be done by many ways:

1. Diet: This described for some genetic metabolism diseases such as phenyl Ketonuria.
2.Physiotherapy: This described for cystic fibrosis patients, so the patients have many sessions which hitting on the back and the chest will be used to get the sticky mucus from the lungs.
3. Using certain injections for some diseases such as insulin injection which are used to treat urine diabetes and the injection of blood clotting protein to treat Haemophilia.
4. Using some surgical operations for the embryo (limited cases) to repair some genetic abnormalities.
5. Treatment by the genes, exchanging the gene which suffers problems in function, that's by reducing the symptoms of disease which the original gene is responsible for it.

Genetic counselling

Many people with a family history of a genetic disease also undergo genetic counselling, the process of informing a person or couple about their genetic makeup. Genetic counselling is a form of medical guidance that informs individuals about problems that might affect their offspring. By studying the data from genetic screening tests and the family's pedigree, a genetic counsellor can predict the likelihood that a couple will produce an affected child. For diseases that have both genetic and environmental influences, such as diabetes, physicians and counsellors can advise families on how to lower risk factors.

The fields which can be counselled:

1. Know the range of affecting some members of the family by one of the genetic diseases.
2. Know what leads to (relative marriage) possible genetic diseases.
3. Know the causes of irregular sexual formation or late sexual maturity.
4. Give advises in case of frequent miscarriages.
5. In case of identifying the father.
6. In case of finding out the danger of medicines and radiation.

Human Genome

After a half century of discovering the structure of **DNA**, genetic scientists knew the genetic successive or human genome which includes order of about 3,3 billion pairs of nitrogen's bases in human chromosomes. Scientists looking forward to know the information which the nucleotides succession will determine for **DNA** real terms.
That's by developing new and important field of biology fields (**Bioinformatics**) which is aiming to program the computer to help to explain and analysis most of **DNA** nucleotides successive and expect genes presence places and the functions which control by it, also comparing between successive of different nucleotides for **DNA**.

Molecule base for genetic

Mendel through his study for many traits in plant of peas concluded that there are genetic factors controls transferring the traits in the organism, but what are these factors, what its procedure to store the genetic information and its ability to solve the vague information which puzzled the scientists. Later through their studies and researches could solve some aspects of that puzzle by insistence of scientists to find the solution for one the respiration system's diseases which was spread in the society in **1928** .

Detection of DNA

Scientists depended on three studies definite that **DNA** is the genetic material:
1. Krevet experiments on bacteria, so he explained that there is genetic factor which did the **Transformation**; he could transfer the ability of killing between types of bacteria cells.
2. The experiments of **Avery** showed that **DNA** and not the protein are responsible of **Transformation** in bacteria.
3. The experiments of **Hershey** and **Chase**, these two scientists in (1952m) had a test to know if (the DNA or the protein) is the genetic material which the virus transfer it or **bacteriophages**. Can explain this experiment in three steps:

• Radiation was used to distinguish **DNA** from the protein in virus, so radiated phosphor (P^{32}) was used for the **DNA** and the radiated sulphur (S^{35}) was used for the protein. After that the two scientists left the virus which contains the radiated phosphor and the one which contains the radiated sulphur individually to affect the bacteria (**Escherichia coli**).
• The layers of virus were removed from the cells by certain processer.
• The viruses were separated from bacteria by using **Centrifuge**. The result was all viruses' **DNA** a little bit of protein interred to bacteria. On that base it was concluded that the part of virus which affected bacteria cell and multiplying its **DNA** not its protein.

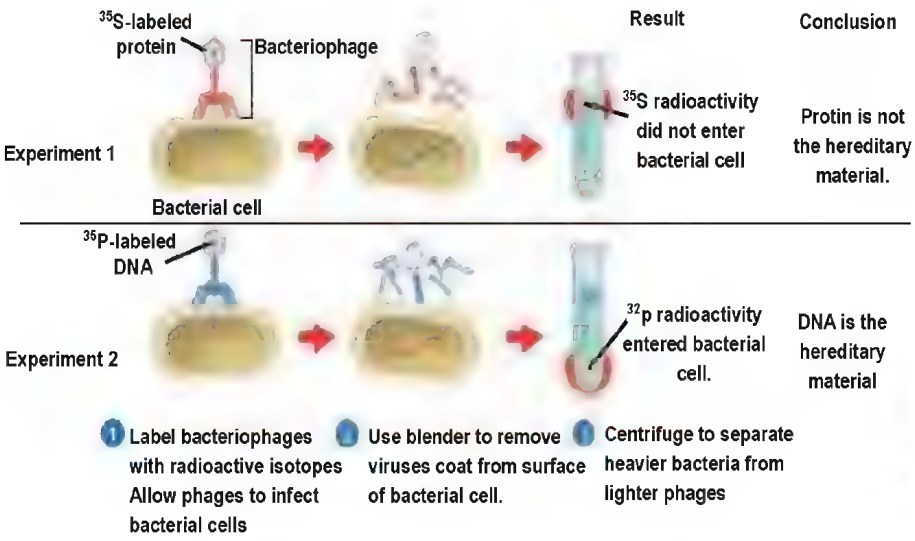


Figure 5.35
Hershey and Chase, had a test and concluded that DNA is the genetic material which the virus transfer it. (for study)

Figure 5.36 Double helix form of DNA. (for study)

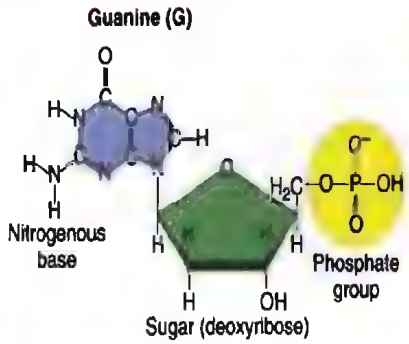


Figure 5.37 A) Structure of nucleotide (for study)

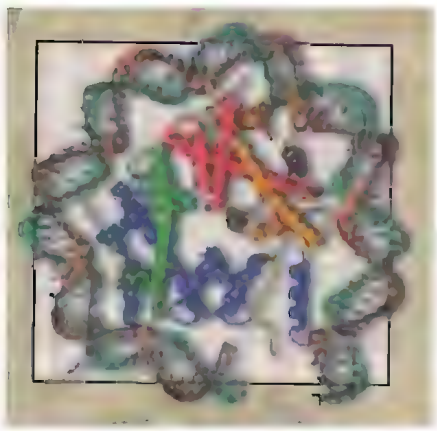


Figure 5.37 B) Structure of nucleosome (for study)

The structure of DNA

Until the year **1953** the biology scientists were proving the idea of **DNA** is the genetic material but before that time they didn't know the structure of **DNA**, then two scientist **Watson** and **Crick** put the idea for **DNA** structure; it is basically consist of two **anti-parallel chains**, one of them turns around the other one in a shape of double spiral and the nitrogenous bases for one of the chains connects with the bases which are relate (complementary) in the opposite chain by hydrogen bonds, also the sugar circles and phosphate group in each of the chains by covalent bonds.

Deoxyribonucleic acid (DNA) is regarded as a complex chemical compound. It is present in all living organisms and it is important. It is present mainly in the nucleus within the chromosomes which forms from the chromatin reticulum, and the chromatin material forms from units of **Nucleosome** which is consist of four molecules of histone each one presents in dual case, **DNA** molecule includes this structure. **DNA** also presents in some cytoplasmic organelles as in mitochondria and plastids.

Molecules of **DNA** is the biggest bimolecules, as polysaccharides are consists of number of units or small molecules which are monosaccharide, the proteins are consist of number of units or smaller molecules which are amino acids, so the nucleic acids are consist of a big number of frequent building units called **Nucleotides**.

Each Nucleotide consists of three simplest molecules connected with each other directly it is from out to inside as follows:

1. Pentose sugar which called **Deoxyribose**, the molecule form is ($C_5H_{10}O_4$).

2. Phosphate group: This consists of an atom of phosphate (**P**) is connected by four atoms of oxygen (**O**).
The alternate molecules for phosphate and sugar forms the two sides of **DNA** chain, so the nucleotides which are on the way of each chain connects by covalent bonds combines between the sugar of one of the nucleotides and phosphate group for the other nucleotides. The **covalent bond** is unites two atoms as a result of corporation of each one of them by an electron. The sugar and phosphate are identical in each nucleotide.

3.Nitrogenous Base is a ring compound which contains nitrogen, in addition to carbon, hydrogen and oxygen except **adenine** which doesn't contain oxygen. The distance between each base and another one is constant.

Types of Nitrogenous Bases

1-Pyrimidine: includes the following normal bases:

1) **Thymine (T)** it is available in **DNA** only.
2) **Cytosine (C)** it is available in both nucleic acids.
3) **Uracil (U)** it is available in **RNA** only.

B-Purines: includes two bases:

1) **Adenine (A)** it is available in **DNA** and **RNA**.
2) **Guanine (G)** it is available in **DNA** and **RNA**.

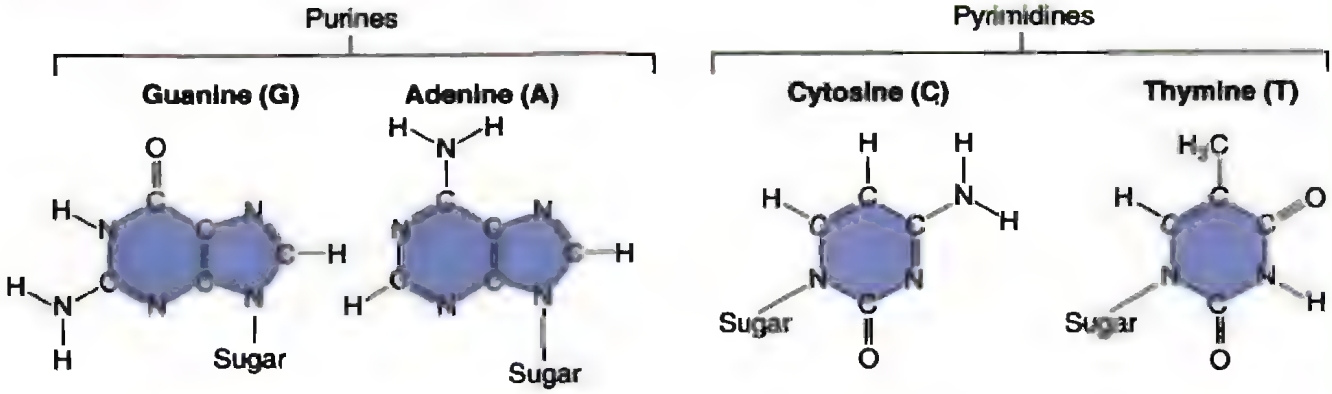


Figure 5.38 Structure of purine and pyrimidine nucleotides (for study)

The linkage of the bases between two chains is not random, but it is bounded, so adenine in one of the chains always connects with thymine in the other chain by two hydrogen bonds, and cytosine in one of the connects with guanine in the other chain by three hydrogen bonds.

In 1949(A.C) the scientist Chargaff ingratiate that the percentage for Adenine equals the percentage for Thymine, also the percentage for Guanine equals the percentage for Cytosine in the DNA for a various group of organisms and these pairs of bases are called Complementary base pairs.

So the order of the bases in one chain of the DNA molecule or RNA is complementing for the structure of the bases in the opposite chain. For example the chain of **DNA** with order **AGAC** the opposite chain will be in completing order **TCTG**

Complementary base pairs are important in **DNA's** structure and function for two reasons:
1) Because the bonds between the base pairs helps to hold the two DNA chains.
2) Because of complementary nature for the DNA helps to explain how it is replication before the cell division.

Example: If you know the succession of the bases in one of the **DNA** chains is: **TCT GTG GAC**. How the complementary bases will be in the opposite chain?

Solution:
The succession of the given bases is: **TCT GTG GAC**
The supplement succession will be : **AGA CAC CTG**

The above shows the **DNA** is very important, because it is the forming material for the genes, the succession of the nitrogen's bases determines the traits of organisms.

Structure of RNA and its functions

Ribonucleic acid (**RNA**) is available in the nucleus and in the cytoplasm as the case in the nuclei, and in ribosomes and in other structures. This acid can be the genetic material for some viruses; also it is very important in protein synthesis and the enzymes. This acid is similar to the **DNA** in chemical building units, but it differs in limited aspects as the following:

1) **RNA** contains ribose sugar $C_5H_{10}O_5$ instead of ribose sugar missing oxygen $C_5H_{10}O_4$ which is in **DNA**.
2) **RNA** contains nitrogen base Uracil instead of the base Thymine which is in **DNA**.
3) **RNA** usually consists of one chain not two as in **DNA**. But some parts of the RNA may bends to become binary chain, in that Uracil connects with Adenine and Cytosine connects with Guanine.
4) **RNA** is short (nearly equals the length of one gene) but he **DNA** is a huge molecule contains hundreds or thousands of genes.
5) **RNA** carries instructions of protein synthesis, but the **DNA** can give the instructions only.
6) **RNA** can behave as enzyme, but **DNA** can't do enzyme function.

RNA Types:

We will mention three types of **RNA** and all of them are made in nucleus of the cell and transferred to cytoplasm, so it has role in protein synthesis and they are:

1) Messenger (mRNA): it is a molecule transfer genetic message from **DNA** which is available in the nucleus to the ribosomes which is available in the cytoplasm in the cells of eukaryotes.

2) Ribosomal(rRNA): it is part of the structure of ribosome; it shares with protein in its formation.

3)Transfer (tRNA): it transfers amino acids to the ribosome for protein synthesis. It was noticed the amino acids connect to this acid (**tRNA**) before transfer it to the ribosome.

Genetic Code and Messenger RNA

Genetic Code points out the succession of nitrogen's bases in **mRNA** (**Messenger RNA**) so three nearby nucleotides represents Codons and determine an amino acid or points to the beginning of Initiation or to stop the translation.

Replication of DNA

The main property for the genetic material **DNA** is the ability to replication in the beginning of each cell division to make sure transferring it to the new cells.

Replication's steps:

1) **Helicase** enzymes separate the **DNA's** chain, so these enzymes transfer on the length of this molecule to open the hydrogen's bonds between the complementary bases. The product of separation these two chains is an area looks like the shape of letter (**Y**) which is called replication fork.

2) The enzymes of **DNA Polymerase** adds completing nucleotides which are inside nucleus to each one of the original chains and off course the covalent bonds form between nearby new nucleotides, also the hydrogen's bonds forms between the complementary bases which are on the original and new chains.

Notice the direction of the arrows in this figure at replication fork that building the **DNA** is in opposite direction in each chain this leads to make holes in the chain which is forming recently, but these holes get connected in between them by an enzyme called **DNA Ligase**.

3) **DNA Polymerase** enzymes ends the replication and then separate from it and produces two separated molecules in each chain, one of them is original and the other one new, so this kind of replication called **Semi-Conservative Replication.**

The replication is carefully done, so one mutation can happen for each one billion of added bases pairs, the reason is the presence of **DNA polymerase** enzymes which mostly repairs the mistake.

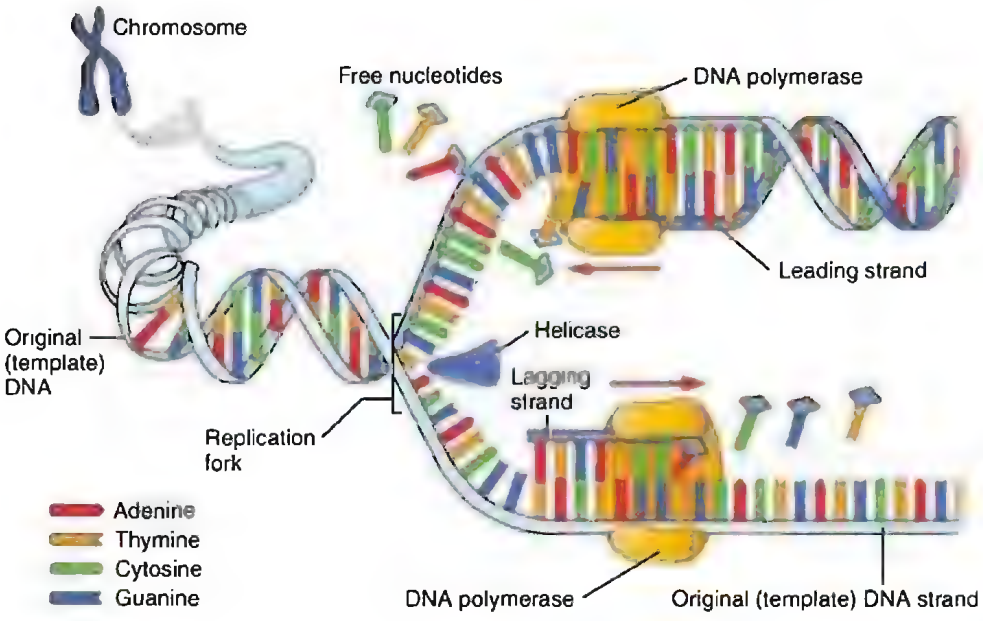


Figure 5.39 Stages of DNA replication (for study)

DNA and its ability to Transcript the RNA

Transcription is the building operation of **RNA** by using one chain of **DNA** as template. **Transcription** is regarded as the first stage of protein synthesis, the steps of transcription as follows:

1- **RNA** polymerase enzyme which is the enzyme that stimulates producing **RNA** from the **DNA** template connects in Promoter situation that leads to untie the wrapped **DNA** chains and their separation.

2- **RNA** polymerase enzyme adds **RNA** free nucleotides to the nucleotides which are in one of the **DNA** chains and it produces a new **RNA** chain. As the case in **DNA** replication so the pairs of complementary bases determines nucleotides succession in **RNA** which is made recently.

For example;

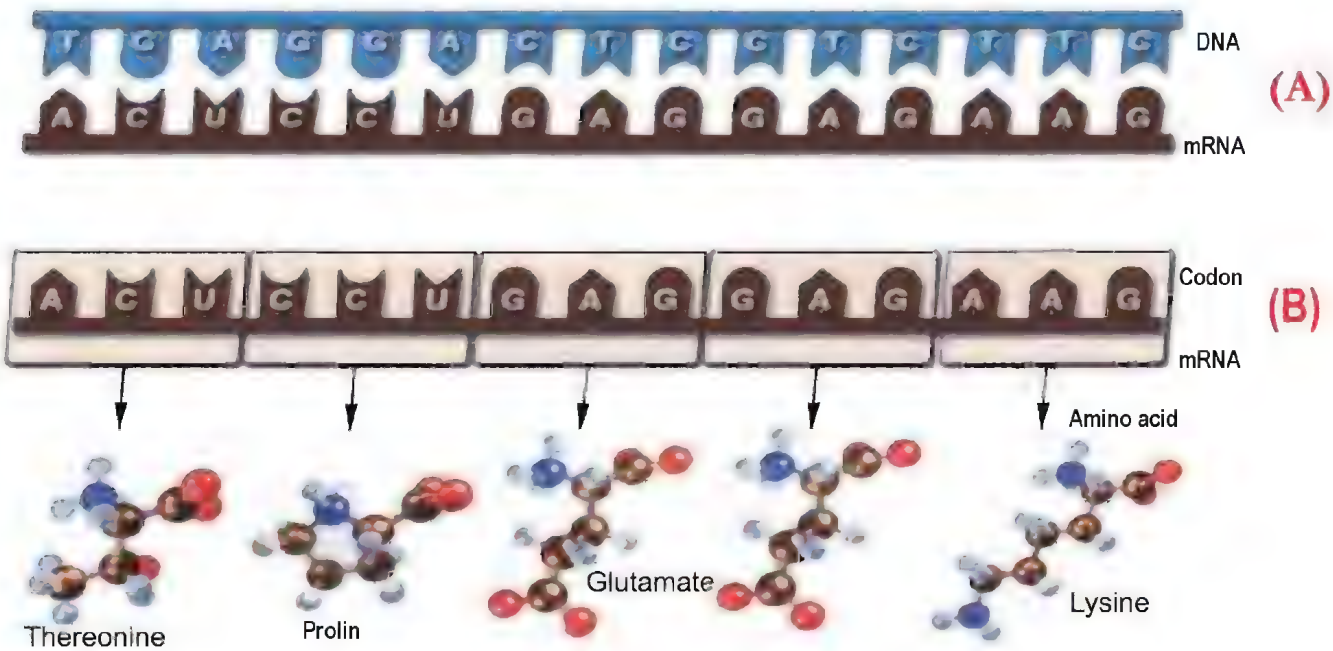
If the succession of the bases in **DNA** chain is: **C A G C T A** so the succession of bases in **RNA** chain will be as the following:

Succession of the bases in **DNA** chain **C A G C T A**
Succession of the bases in **RNA** chain **G U C G A U**

After **RNA** polymerase enzymes have left the area of gene which had been transcript, the DNA chains wrap again.

3- After **RNA** polymerase enzyme arrives to the ending signal it releases new **RNA** with different types.
The product **RNA** may perform its function in the cell. The enzyme can transcript another gene.

Figure 5.40 It shows the stages of production of amino acids from genes. Each three nucleotide form a codon and each codon used to produce an amino acid. (for study)



DNA Translation for protein synthesis

Translation is regarded as a step in protein synthesis and it happens in the ribosomes and codons have been used in **mRNA** molecule for the determination of amino acids succession in polypeptides chain and include three main steps:

1) Initiation Stage: **tRNA** connects with **mRNA** and two building units for the ribosome with each other. Certain enzymes connects the amino acid methionine at one of the tRNA sides according to initiations codon **AUG** in the **mRNA** which couples with anti-codon **UAC** on the other end for **tRNA**. The amino acid methionine is regarded as the first nearly in all polypeptides but it may disappear later.

2) Elongation Stage: In this stage the chain of polypeptides form, the anti-codon in **tRNA** which carries the suitable amino acid couples with the second codon in **mRNA**, follows the separation of methionine from the first **tRNA** under the action of ribosome. Then a peptides bond forms between methionine and the second amino acid. Also the first tRNA leaves the ribosome and the ribosome moves forward alongside with the molecule of mRNA one codons distance.

3) Termination Stage: When the ribosome arrives to the stopping codon like **(UGA or UAG or UAA)** on the **mRNA** this leads to separation of polypeptides chain which was formed from last tRNA and a release happens in the cytoplasm with leaving last **tRNA** for the ribosome, also the two building units for the ribosome separates from each other and the ribosome moves away from **mRNA**.

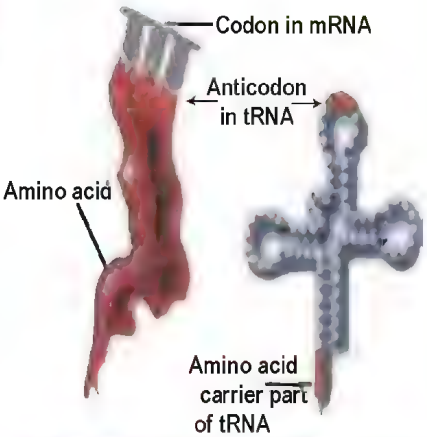


Figure 5.41 A typical type of tRNA. (for study)

Translation of **mRNA** doesn't get completed only after the transcription which was mentioned before is ended, this is in eukaryotic.

In prokaryotic that don't have nucleic membrane separates its nucleic acid (**DNA**) from ribosomes which is present in the cytoplasm, so it can start the translation before the transcription ends. A new ribosome can start the translation of **mRNA** in case the previous one retires, therefore many ribosomes may translate the same copy of **mRNA**, and this kind of translation is called **polysome.**

Structure and function of protein:

The shape of protein has a big influence on its function. Each protein consists of one or more polypeptides, which are chains of amino acids and is connected by peptide bonds. There are (20) different amino acids in the protein of organisms. The chain of polypeptides consists of hundreds or thousands of the (20) different amino acids which are ordered according to special succession which gives three dimensions structure for the protein.

Genetic Engineering

It is the techniques of changing the genetic structure for the living cells or the individuals through removing some genes or hybrid a new molecule of DNA or altering it to enable the cell or the organism to gain the desirable traits. The following are main needs for the technique of genetic engineering:

1. A method of cutting down the molecules of **DNA** which carries the required gene to transfer by one of the restriction enzymes.

2. A suitable carrier which carries the new piece of DNA. This take place through it's unite with **DNA** carrier with the help of DNA Ligase enzyme, so the hybrid piece (**rDNA**) marked by its ability to replication inside the recipient cell.

3. A method to enter the hybrid piece of (**rDNA**) including the carrier piece for the gene that is going to be transferred to the recipient cell.

4. A method of finding the recipient cell and its generations which carry the desirable hybrid piece and separate it from the rest of colonies members who doesn't contain that piece.

The following is a summary of some of these needs:

1. Restriction enzymes:

These are bacterial proteins which are used to know the certain succession of nitrogen bases for the **DNA** molecule and it's cutting down. Also these enzymes break the internal phosphate bonds for the **DNA**.

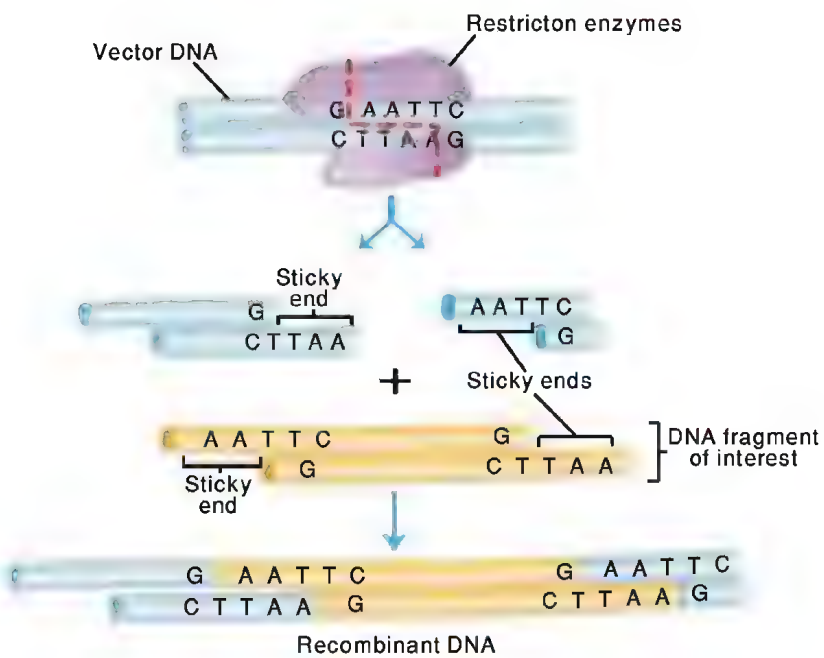


Figure 5.42 It shows the activities of restriction enzyme(Eco RI) (for study)

2. The carrier:

The carrier has a main role in this technique and they are the following:
First: Bacteriophage: Phages are simple structured viruses which affect the bacteria or remains inactive. It contains single or double DNA strips or it may contain single RNA. An example for this is the phage lambda.
Second: Plasmid: It is a small circular from the additional DNA molecule which is present in many bacteria.

- It carries a small number of genes which are responsible for some traits like Bacterial resistance for the antibiotic.
- It replicates itself independently from the bacterial chromosome.
- It can be transferred from one bacterium to another and for many organisms such as yeast, fungus and insects.

3. The Probe and finding the desirable gene

Probe is the molecule of **DNA** or **RNA** which is mono- chain and it is marked by radioactive phosphor and complement for the **DNA** desirable succession and it is required to find it, as a result of connection between the probe with complementary **DNA** piece will form a double radioactive spiral.

As for the insulin gene given in the probe is regarded as the **RNA** for this gene. Usually the specialists transfer the **DNA** from the re-structured bacteria into filter paper for the purpose to find out if the bacteria contains the desirable gene, when the bacteria is viewed under ultra violet rays or when it is exposed to photographic film, the **clones** cells which carries desirable **DNA** and is distinguished by the probe stuck to it and it will become light and shiny.

Genetic practices

1. Determine the succession of complete nucleotides (Human genome) to know the genetic map.
2. Its used in justice field.
3. Its used in the field of following the human immigration and some other organisms from its environments especially the ones threatened by extinction.
4. Producing human insulin hormone, protein interferon material, clotting factors number (8), blood protein and different vaccinations.
5. Transferring the trait of nitrogen fixation to other types of bacteria.
6. Transferring the trait of root nodules formation in the beans plant to other plants which are economically important.
7. Developing researches of using the bacteria in research field about presence and purification and concentration of the minerals in the soil.
8. Developing the ability of micro organisms to limit some dangers of pollution.
9. Applying selection systems in marriage of disdains of cows, sheep, horse, chicken, fish and others.
10. Applying genetic concepts such as artificial selection and hybridization and regular birth to produce useful plants for humans in big amounts, also taking the advantage of twin's phenomenon in cows and sheep to produce useful animals.

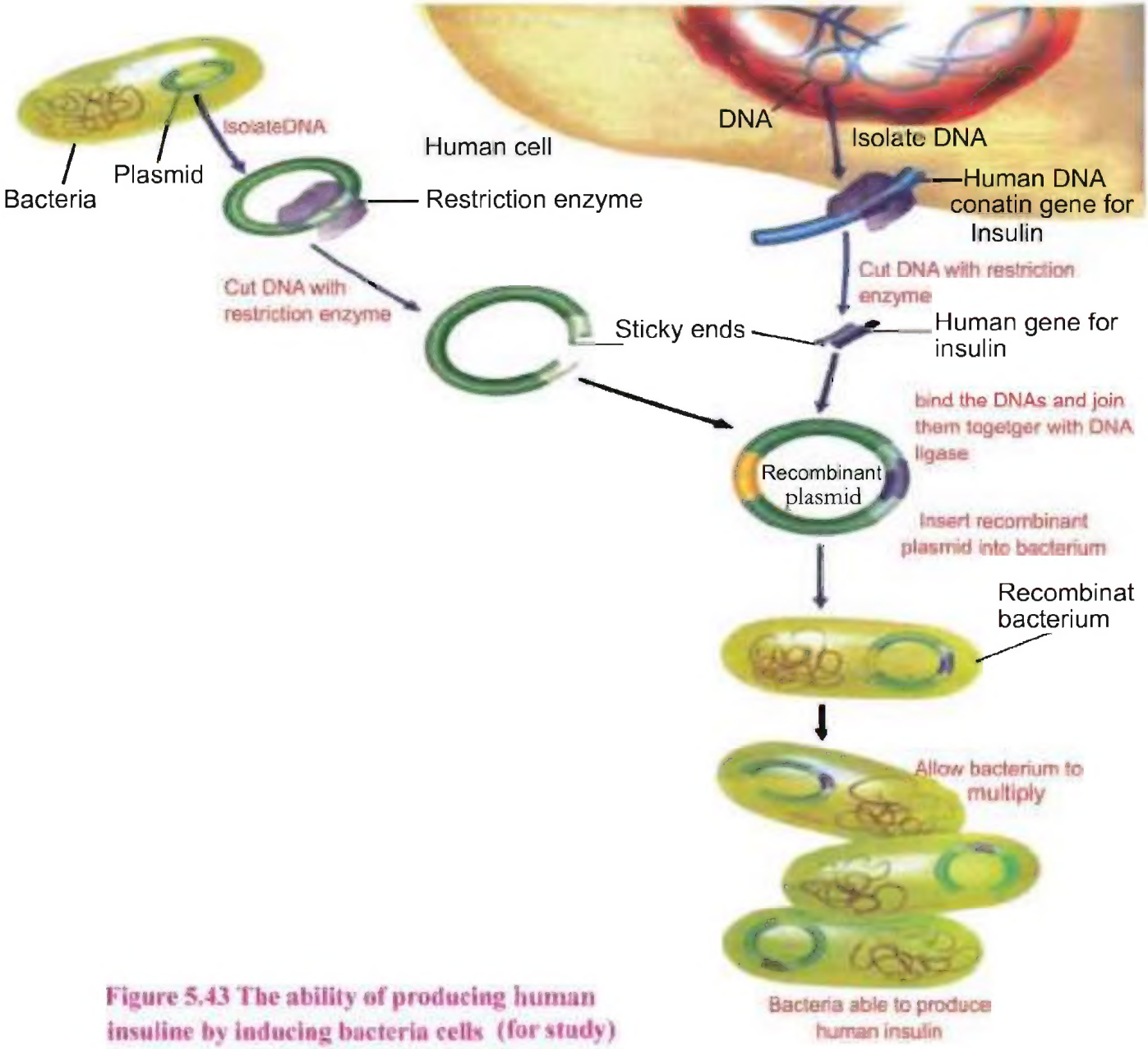


Figure 5.43 The ability of producing human insuline by inducing bacteria cells (for study)

Review

Q1) Define the following:
Genetics, Monohybrid Cross, Heterozygous, Mendel's first law, Restriction Enzymes, Probe, rRNA, sex-linked traits, Lethal alleles

Q2) Mention the properties of the scientist Mendel which made him famous in genetics.

Q3) Mention some scientists who contributed in the progress of genetics with pointing out their best achievements.

Q4) What is the meaning of Phenotype (P) and Genotype (G) and give some examples.

Q5) A man with blue eyes got married with a women with dark brown eyes, they had a number of children all of them had light brown eyes. Explain the genotype for all these people according to the rules of multiple genes.

Q6) The plant of peas with red flower was crossed by another one with white flower, all the product plants where red flowered plants and if you fertilize one of the first generation individual with one of the parents, what are the Phenotype and Genotype for the individuals of second generation, and what is the type of cross in this case?

Q7) Guinean pig with rough, black hair was crossed by a female with rough, white hair, they had a number of births as the following: 3/8 rough black, 3/8 rough white, 1/8 smooth black, 1/8 smooth white: what are the genotypes for the parents and the product individuals? The traits of the rough hair and the black colour are dominant.

Q8) In yellow mice (Yy) the Allele (Y) will be lethal, when intercourse takes place between those, all the pure yellow colored individuals die. Explain the phenotype for all live individuals only.

Q9) An intercorse took place between Mexican dogs with normal hair by another one with no hair, half of the first generation individuals were with normal hair and the other half with no hair, when intercours took place between dogs with no hair, the individuals of product generation where as follows: 1/4 normal hair, 1/2 with no hair, 1/4 with no hair dead. Explain this result with trying essential cross.

Q10) In Drosophila melanogaster the intercourse of (normal wings x obtuse wings) gives individuals as: 1 with normal wings (folded wings), also the (obtuse wings x normal wings) gives individuals as: 1 with obtuse wings: 1 with normal wings. How do you explain these results i.e: The obtuse wings are dominant trait.

Q11) Mention the properties of the used animals in genetic experiments?

Q12) A left handed man who infected with haemophilia, got married with a right handed woman who carries the disease. Half of the children (boys) were affected by the disease, half of the girls carrying the disease, also they had two normal children within this generation, and one of them was left handed. What is the possible genotypes for all the children in this family, given that right handed and not affected by haemophilia are dominant traits.

Q13) The disease of Color Blindness is caused by a recessive, sex-linked gene, if an effected woman got married to a normal man, what are the expected phenotypes for their children with respect to this trait.

Q14) What are the Phenotypes and Genotypes for the blood groups for the children of each couple?

A) I^AI^B X I^BI^O
B) I^BI^O X I^BI^O
C) Hybrid man A X pure woman B.
D) Man Rh+ X woman Rh-.

Q15) A man with blood group A got married with a woman with blood group B, Rh is positive for both, they had two children one of them with blood group O- and the other one with blood group A+, what are the Genotypes for the parents and the children?

Q16) In which cases is the fetuslife in danger, with explaining the reason, when the embryo is with Rh+:

A) When the man is Rh- and the woman is Rh+.
B) When the man is Rh+ and the woman is Rh-.

Q17) Mention the reasons of blood transfusion failure in some cases?

Q18) Explain the following:

1. The people with blood group (O) are described as general donors.
2. When crossing creeping cock with creeping chicken, the quarter of the product was dead.
3. Appearance of dusty individuals when crossing female sheep (short horns, red hair) with male sheep white hair.
4. Mongolian is regarded as chromosome mutation.

Q19) A plant with long stem, how can you know about of the purity of the dominant trait in it?

Q20) Is it possible and why?

1. Having a child blood group (O) from mother (B)and father (AB).
2. Blood Transfusion from any person to another one who is same blood group.
3. Finding unlimited number of Alleles for each gene.

Q21) Write the responsible Gene about:
1. Baldness 2.Hemophilia 3.Chinchilla rabbit 4.Color Blindness 5.Sickle-cell anaemia.

Q22) Mention the difficulties which the scientists faces when doing genetic experiments on human.

Q23) Mention the steps which the techniques of Genetic Engineering include.

Q24) Explain by drawing the method of transferring insulin gene in the human to bacteria and obtaining a hybrid gene (Reformed).

Q 25) Compare between the molecules of DNA in each of the Nucleus and the cytoplasm.

Q 26) Do the functions of some genes be affected by the environmental circumstances? Explain by giving an example.

Q 27) When does Paramecium orelia becomes killing and when does it become sensitive, Mention the genotype for each.

Q 28) What is the relation between the plasmid and the rDNA?

Q 29) The following symbols represent succession of Nucleotides in the DNA molecule. TAC GGT CTC AGC

1. What is the succession of copy of mRNA produced from the above succession?
2. What are the Anti-Codons in tRNA which is linked to the copy of mRNA as above?

Q30) Probe is regarded as a chain for DNA or RNA mono recognized by radiated material or by florescent color. How do the genetic scientists use it to determine the location of rDNA?